Elgar
Mod SW 5250

ELGAR

OPERATING MANUAL

for the

SmartWave™

SWITCHING AMPLIFIER

MODEL SW 5250

(ALSO COVERS SW 1750 AND SW 3500)

ELGAR CORPORATION
9250 Brown Deer Road
San Diego, CA 92121

Switching Amplifier
Operation

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SAFETY NOTICE

BEFORE APPLYING POWER to the System, verify that the SW Series unit is properly configured for the user's particular application.

WARNING

HAZARDOUS VOLTAGES IN EXCESS OF 280 VRMS, 600V PEAK MAY BE PRESENT WHEN COVERS ARE REMOVED. QUALIFIED PERSONNEL MUST USE EXTREME CAUTION WHEN SERVICING THIS EQUIPMENT. CIRCUIT BOARDS, TEST POINTS AND OUTPUT VOLTAGES MAY ALSO BE FLOATING ABOVE (BELOW) CHASSIS GROUND.

Installation and servicing must be performed by QUALIFIED PERSONNEL who are aware of properly dealing with attendant hazards. This includes such simple tasks as fuse verification.

Ensure that the ac power line ground is properly connected to the Model SW Series unit input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment MUST be properly grounded for both personnel and equipment safety.

Always ensure that facility ac input power is de-energized prior to connecting or disconnecting the input/output power cables.

In normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, **HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY** may be normally generated on the output terminals. The Customer/User must ensure that the output power lines are properly labeled as to the SAFETY hazards and any that inadvertent contact with hazardous voltages is eliminated.

Guard against risks of electrical shock during open cover checks by NOT TOUCHING any portion of the electrical circuits. Even when power is OFF, capacitors may retain an electrical charge. Use SAFETY GLASSES during open cover checks to avoid personal injury by any sudden component failure.

Due to filtering, the unit has high leakage current to the chassis. For this reason it is essential to operate this unit with a safety ground.

Some circuits are live even with the front panel switch turned off. Servicing, and even fuse verification and connecting wiring to the chassis, must be accomplished with the power removed via external means; all circuits and/or terminals to be touched must be safety grounded to the chassis. This should be accomplished after waiting at least five minutes after the last power application to the unit.

After the unit has run for some time the metal near the rear of the unit may be hot enough to cause injury. Let the unit cool before handling.

Qualified service personnel need to be aware that some heatsinks are not at ground, but are at high potential.

European versions use 380V 3-phase power. These systems **must have neutral connections; the neutral must not be switched**. Neutral needs to be applied before phase voltage is applied or serious damage to the equipment may result.

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SECTION I

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Elgar Model SW 5250 uses transformerless, direct coupled amplifiers and a true arbitrary waveform generator based controller. This technology allows the user to create, edit and generate complex SmartWave™ waveforms with high DC content for critical ATE and power line disturbance simulation testing.

The SW 5250 can create complex waveforms with high DC content for simulating real world power irregularities, including phase controlled sub–cycle or multi–cycle dropouts, spikes, sags, surges, frequency excursions, plus frequency and voltage ramps (sweeps). The unit can also generate clipped waveforms, harmonic distortion, high current inrush and other complex waveshapes.

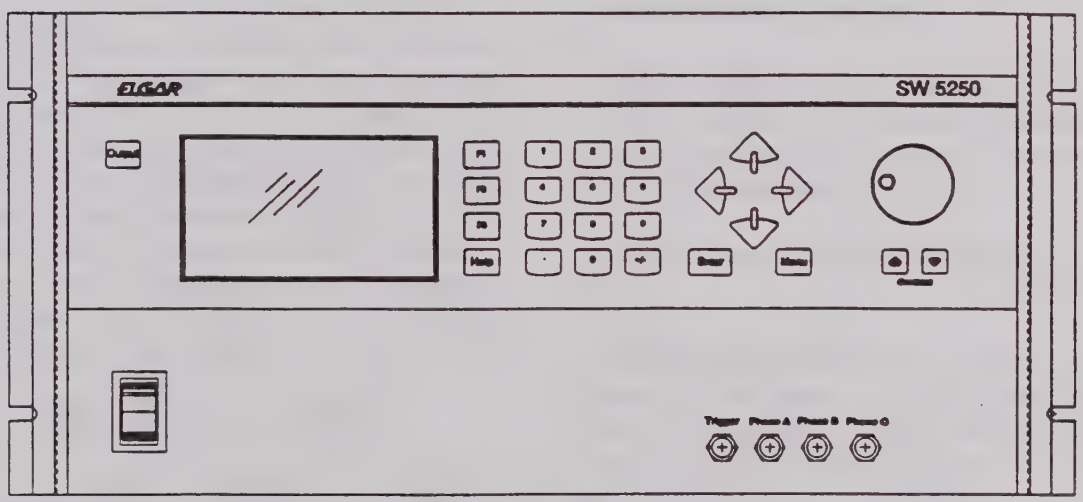


Figure 1–1. Elgar Model SW 5250 AC Power Source (Rack Mount Version)

Programming can be accomplished from the front panel or with a personal computer (PC) using optionally available software. A GPIB card in the computer is also required.

A library of 50 factory–supplied waveshapes is provided in Read Only Memory (ROM). Non–volatile memory storage is available for an additional 50 user–created waveshapes.

Waveshapes from the libraries can be assigned amplitude and frequency parameters and be stored as setups in non–volatile memory for immediate user recall. In addition, up to 1000 timed segments can be created by the user and linked together to form sequences (transient programs).

A back lit graphics LCD display allows quick confirmation of waveforms when created or edited from the front panel. Front panel BNCs provide waveform reference outputs for oscilloscope viewing. The front panel includes a keypad, knob and Help screens.

The SmartWave™ sources are true DC as well as AC power supplies. Up to 312 VRMS are available in AC or AC+DC modes. Multi-phase models can be switched to single or three-phased operation via the front panel or the GPIB.

A wide frequency range of DC or 40 Hz to 5 kHz is available for a broad array of applications. Utilizing the latest in AC switch mode technology, the SW 5250 achieves 55 dB of noise and ripple with total harmonic distortion (THD) of <0.5% to 500 Hz. A crest factor of 4.0 provides high peak-to-RMS current capability. An optional power factor correction (PFC) of .99 is also available.

1.2 INPUT SPECIFICATIONS

Input Power Ranges: Factory configured 187 to 264 VRMS, 3ϕ L-L (3 wire), or 342 to 457 VRMS, 3ϕ L-L (4 wire). A chassis ground is also required for safety.

Input Power Factor: .6 (.99 with input PFC option).

Input Frequency Range: 47 to 63 Hz.

Efficiency: 70%, minimum, at full load.

Ride Through: 3 msec, minimum; 10 msec, minimum, with PFC option.

1.3 OUTPUT SPECIFICATIONS

Power Factor of Load: 0 lagging to 0 leading.

AC or DC Output Voltage: 0 to 156 VRMS L-N range 1; 0 to 312 VRMS L-N range 2.

Output Current Per Phase: 13A to 135V in 156V range; 6.5A to 270V in 312V range (1750 VA maximum).

Crest Factor: 4.0 (peak output current to RMS output current).

Output Frequency: DC, or 40 Hz to 5 kHz. For output frequencies greater than 1 kHz, the maximum slew rate allowed is 1 kHz per second.

Output Power: 1750 VA, maximum, per phase.

Total Harmonic Distortion (Full Linear Load or No Load): 0.25% maximum, 40 to 100 Hz; 0.5% maximum to 500 Hz; and 1% maximum to 1 kHz plus 1%/kHz to 5 kHz.

AC Noise Level: 55 dB RMS below full output.

Amplitude Stability With Remote Sense: ±0.1% of full scale over 24 hours at constant line, load and temperature.

Load Regulation: ±0.025% of full scale voltage for a full resistive load to no load; above 1 kHz, add ±0.01%/kHz.

Line Regulation (DC, or 40 Hz to 5 kHz): ±0.025% of full scale for a ±10% input line change.

Voltage Accuracy: ±0.1% of range. Above 1 kHz, add 0.2%/kHz. Add ±0.1% of full scale for "AC PLUS DC" mode. Valid for 5 to 156 VRMS and 10 to 312 VRMS at 25°C (77°F).

Voltage Resolution: 0.05% of full scale.

Frequency Resolution:

- 0.01 Hz: 40 to 99.99 Hz
- 0.05 Hz: 100 Hz to 999.9 Hz
- 0.5 Hz: 1000 Hz to 5000 Hz

Frequency Accuracy: ±0.01% at 25°C ±0.001%/°C.

Phase Accuracy, Phase-to-Phase Balanced Linear Resistive Load: ±1°, 40 Hz to 1 kHz, plus ±1°/kHz above 1 kHz.

Phase Angle Resolution: 0.1°.

Remote Output Voltage Sense: 5 VRMS total lead drop, maximum.

1.4 WAVEFORM SPECIFICATIONS

Waveshape Libraries: 50 factory supplied in ROM; storage available for up to 50 user created in non-volatile RAM.

User Created Setups: A total of 100 steady-state waveforms, consisting of parameters such as waveshapes from the libraries plus amplitude, frequency, phase angle and current limit.

Sequencing/Transient Programs: 1000 user-created segments stored in non-volatile RAM. Segments include waveshape, amplitude, frequency, phase angle, **time** (from 1 msec to 7 days), and number of cycles.

MIL-STD-704 Transients

1.5 STANDARD MEASUREMENTS

1.5.1 Parameters Measured

- 1- to 3-Phase to Neutral RMS Output Voltages
- 1- to 3-Phase to Phase Voltages are Calculated
- 1- to 3-Phase RMS Output Currents
- 1- to 3-Phase Peak Current
- Output Frequency
- 1- to 3-Phase Power
- 1- to 3-Phase VA
- Power Factor of Load Calculated from 1 or 3 Phases
- Output Phase B and C Relative to Phase A

1.5.2 Measurement Capabilities and Accuracies

1.5.2.1 Measurement Capability

4.5 Digit Analog to Digital Measurement System

Calibration Interval: 6 months.

Temperature Range for Specified Accuracy: 25°C ±5°C.

Operating Temperature Range: 0°C to 45°C (32°F to 113°F).

1.5.2.2 Phase to Neutral RMS Voltage Measurement

Valid for phases A, B and C (use phase A for Parallel Mode).

Range: 0V to 350.0V plus sign bit for DC range.

Accuracy: ±0.3% of range, DC or 47 Hz to 1 kHz; ±0.5% of range, 40 to 47 Hz and for 1 kHz to 5 kHz.

Temperature Coefficient: ±200 ppm outside specified range.

1.5.2.3 Phase to Phase RMS Voltage Calculation

Calculated from Phase to Neutral voltages and phases.

Range: 0V to 700V.

Accuracy and **Temperature Coefficient** the same as for the Phase to Neutral voltage (see paragraph 1.5.2.2).

1.5.2.4 RMS Current Measurement

Valid for phases A, B, and C (use phase A for Parallel Mode).

Range 1: 0A to 7.5A plus sign bit for DC range; 3-phase mode, 312V range.

Range 2: 0A to 15A plus sign bit for DC range; 3-phase mode, 156V range.

Range 3: 0A to 22.5A plus sign bit for DC range; parallel mode, 312V range.

Range 4: 0A to 45A plus sign bit for DC range; parallel mode, 156V range.

Accuracy: ±1.0% of range, DC or 40 Hz to 500 Hz; add ±1.5%/kHz above 500 Hz. Accuracies are specified for a maximum crest factor of 4.0.

Temperature Coefficient: ±300 ppm outside specified range.

1.5.2.5 Peak Current Measurement

Valid for phases A, B, and C (use phase A for Parallel Mode).

Range 1: 0A to 28A; 3-phase mode, 312V range.

Range 2: 0A to 56A; 3-phase mode, 156V range.

Range 3: 0A to 84A; parallel mode, 312V range.

Range 4: 0A to 168A; parallel mode, 156V range.

Accuracy: ±5% of range, 40 to 500 Hz; add ±1%/kHz, 500 to 5 kHz.

Temperature Coefficient: ±300 ppm outside specified range.

1.5.2.6 Power Measurement

Valid for phases A, B, and C. Up to 3 phase total power and parallel mode (use phase A for parallel mode).

Range 1: 0 kW to 1.8 kW; 3-phase mode.

Range 2: 0 kW to 5.6 kW; parallel mode and total 3-phase power.

Accuracy: ±2.5% of range, DC or 40 to 500 Hz for crest factors <2.0. Add ±1% for crest factors up to 4.0. Add ±1%/kHz above 500 Hz.

Temperature Coefficient: ±500 ppm outside specified range.

1.5.2.7 VA Measurement

Valid for phases A, B, and C. Up to 3 phase total VA and parallel mode (use phase A for parallel mode).

Range 1: 0 kW to 1.8 kVA; 3-phase mode.

Range 2: 0 kW to 5.6 kVA; parallel mode and total 3-phase power.

Accuracy: ±2.5% of range, DC or 40 to 500 Hz for crest factors <2.0. Add ±1% for crest factors up to 4.0. Add ±1%/kHz above 500 Hz.

Temperature Coefficient: ±500 ppm outside specified range.

1.5.2.8 Power Factor Calculation

Valid for phases A, B, and C (use phase A for Parallel Mode).

The Power Factor is calculated from the Power and VA measurements. Phase powers are measured then the total power is calculated; phase VAs are measured then the total VA is calculated. Power is divided by VA; the result is the Power Factor.

Range: 0 to 1.00.

Accuracy: ±5% of range at full power, DC or 40 to 500 Hz for crest factors <2.0. Add ±2% for crest factors up to 4.0. Add ±1%/kHz above 500 Hz.

Temperature Coefficient: ±500 ppm outside specified range.

1.5.2.9 Frequency Measurement

Frequencies are calculated based on output zero crossing time measurements. To minimize errors due to switching noise, a 1 μs filter is used to filter the output signal before the zero comparator.

Resolution: Frequency is displayed to 5 figures maximum; the leading zeros are blanked. Displayed resolution is 0.01 Hz.

Accuracy: ±0.5% of reading, at 10% to full output voltage, 0°C to 45°C (32°F to 113°F).

1.5.2.10 Phase Measurement

Valid for phases A, B, and C relative to each other.

The phase of measured signals are calculated from timing measurements. The reference is the negative to positive zero crossing of the phase A reference signal or the waveform trigger signal. End of timing is the negative to positive crossing and the polarity signals are used for these measurements. The reference used is menu selectable.

Results for phase A relative measurements are calculated from individual timings and displayed as: Phase 'X' is leading/lagging phase 'Y' by 'Z' degrees.

Resolution: ±1°.

Accuracy: ±2°, 40 to 500 Hz; add ±2°/kHz above 500 Hz. For sine wave, balanced resistive load, 10% to 100% of voltage measurement range. All accuracies are specified for 0°C to 45°C (32°F to 113°F).

1.6 PROTECTION AND SAFETY

Overvoltage Shutdown: Programmable for 60V to 255V peak, 156V range; 120V to 510V peak, 312V range.

Programmable Current Limit Shutdown: Settable to 1% of range (0.5A to 13A for 156V range; 0.5A to 6.5A for 312V range).

Programmable Current Limit with Timed Shutdown: Settable to 1% of range; the timeout is settable from 10 msec to 10 sec.

Programmable Constant Current: Settable to 1% of range (0.5A to 13A for 156V range; 0.5A to 6.5A for 312V range). For all current accuracies, add ±1.5%/kHz above 500 Hz. For paralleled amplifiers, add ±1%.

Overtemperature Shutdown (automatic, not programmable).

1.7 DESIGNED TO MEET THE FOLLOWING AGENCY REQUIREMENTS

- **UL 1244**
- **IEC 1010–1**
- **IEC 555–2**
- **IEC 801–4 and 5**
- **FCC Part 15, Class A**

1.8 PHYSICAL SPECIFICATIONS (Models SW 5250, SW 3500, SW 1750)

Height: 8.75" (222 mm)

Width: 19" (483 mm)

Depth: 23.5" (597 mm)

Weight:

- SW 5250 – 126.5 lbs. (57.2 kg)
- SW 3500 – 100 lbs. (45.4 kg)
- SW 1750 – 73 lbs. (33.1 kg)

Cooling: Air is drawn in from the top, bottom, and sides and exhausted through the rear of the chassis.

1.9 ENVIRONMENTAL DATA

Operating Temperature: 0°C to 45°C (32°F to 113°F).

Storage Temperature: –40°C to 70°C (–40°F to 158°F).

Humidity (Non–condensing): 0 to 85% at 25°C (77°F); derate to 50% at 40°C (104°F).

1.10 OTHER STANDARD FEATURES

- **1– to 3–Phase Programmable**
- **IEEE 488.2 Interface**
- **SCPI Protocol**
- **Waveform Trigger Output** (1 MegΩ Load Drive)
- **BNC Outputs for Waveform Viewing** (1 MegΩ Load Drive)
- **SYNC OUT. User programmed for:**
  - Cycle Start, all cycles
  - Segment Start. all segments
  - Segment Start, selected segments

  For loads ≥2 kΩ: Vout ≤1V Low State; Vout ≥2.4V High State
- **External Amplitude Modulation**
  - 0 to 5 VRMS provides 0 to ≥20% output amplitude modulation.
- **CLOCK/LOCK**
  - **CLOCK** pulses at programmed frequency for loads ≥2 kΩ Vout ≤1V Low State; Vout ≥2.4V High State
  - **LOCK** locks output to input 'TTL' frequency; signal needs to supply pull down current of 15 mA with voltage drop of ≤0.6V; no pull up needed
- **External Drive**
  - Normal Amplifier, 0 to 5 VRMS (DC to 5 kHz) or ±5 VDC input for zero to full voltage output.
- **External Gain Control**
  - 0 to ±7.07 VDC provides zero to full output.
- **External Input Impedance**
  - ≥30 kΩ.

1.11 OPTIONS

- Parallelable For Additional Power above 5250 VA
- External Waveform Creation Software
- Elgar's VXP–1000 Controller For VXI
- Input Power Factor Correction to 0.99
- 5V or 26V, 0.25A Auxiliary AC Outputs

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

SECTION II

INSTALLATION

2.1 INTRODUCTION

The Elgar Model SW 5250 has been fully calibrated and tested prior to shipment. Therefore, the instrument is ready for immediate use upon receipt. The enclosure is designed to be installed in a standard 19" (483 mm) RETMA rack or a transit case; pem-nuts are provided for mounting optional slides.

The following checks should be made to ensure that the instrument was not damaged during shipment.

WARNING

The SW 5250 weighs 126 lbs. (57.2 kg)! A minimum two person lift is required!

WARNING

Hazardous voltages are present when operating this equipment. Read the "SAFETY" notices on page ii prior to performing installation, operation, or maintenance.

2.2 UNPACKING

Perform a visual inspection of the shipping container prior to accepting the package from the carrier. If extensive damage to the shipping container is evident, a description of the damage should be noted on the carrier's receipt and signed by the driver of the carrier agent.

If damage is not apparent until the instrument is unpacked, a claim for concealed damage should be placed with the carrier. In addition, the shipping container(s) and filler material should be saved for inspection. Forward a report of damage to the Elgar Service Department. Elgar will provide instructions for repair or replacement of the instrument.

If the instrument needs to be returned to Elgar, suitable shipping containers and packing materials must be used. If proper packing material is not available, contact Elgar to provide containers and shipping instructions.

2.3 PRE-INSTALLATION INSPECTION

Perform a visual inspection of the instrument when it is removed from the shipping container. Check for shipping damage such as dents, scratches, distortion, and damaged connectors.

2.4 INSTALLATION

The Model SW 5250 is 8.75" (222 mm) high and is designed to be installed in a standard 19" (483 mm) wide cabinet enclosure or a transit case.

CAUTION

Avoid blocking the instrument air intakes or exhaust.

2.5 AIR INTAKE AND EXHAUST

The air intakes are located on the top, bottom, and side panels of the instrument and the exhaust is through the rear panel. Care must be taken not to block the side air intakes; the top and bottom air intakes allow for improved cooling if this air is available. No special vertical separation is required when stacking instruments. However, a 1.75" (45 mm) vertical spacer above and below the instrument may improve cooling. The temperature of the intake air should not exceed 113°F (45°C).

At full power the unit dissipates over 2250W with the PFC option. It is important that the heat produced is properly vented to the exterior of the chassis. Special baffling to control air flow may be required to prevent hot exhaust air being drawn into the intakes if the unit is to be run continuously at full power.

The preferred mounting method for full power operation is bottom mounting. Slide mounting may impair air flow from the side air intakes. If slides must be used, select narrow slides to minimize restrictions to air flow and select cabinets without wide rails which can block air flow. Refer to Table 2–1 for the recommended slides and Figure 2–2 for the mounting location.

2.6 INSTALLATION/DIMENSIONAL DRAWING

Refer to Figures 2–1 and 2–2 for information on outline and mounting dimensions of the SW 5250. Refer to Figure 2–3 and Tables 2–2 through 2–7 for rear panel connector information. Also refer to Figure 2–2 for customer wiring conduit details.

Table 2–1. Recommended Mounting Slide

Type	Manufacturer	Part Number
Mounting Kit (for slides)	Jonathan	BK–3
Slides	Accuride	C–3307–16D

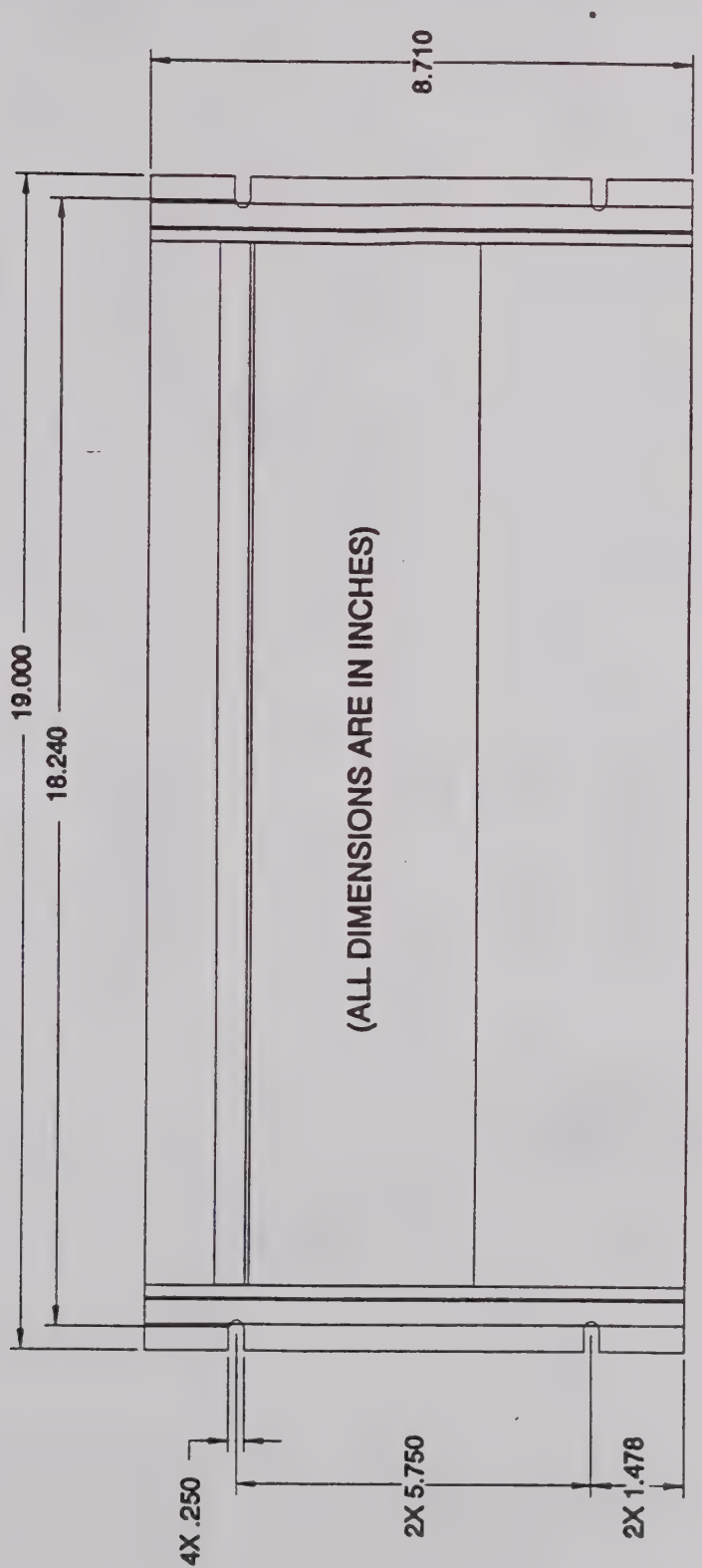
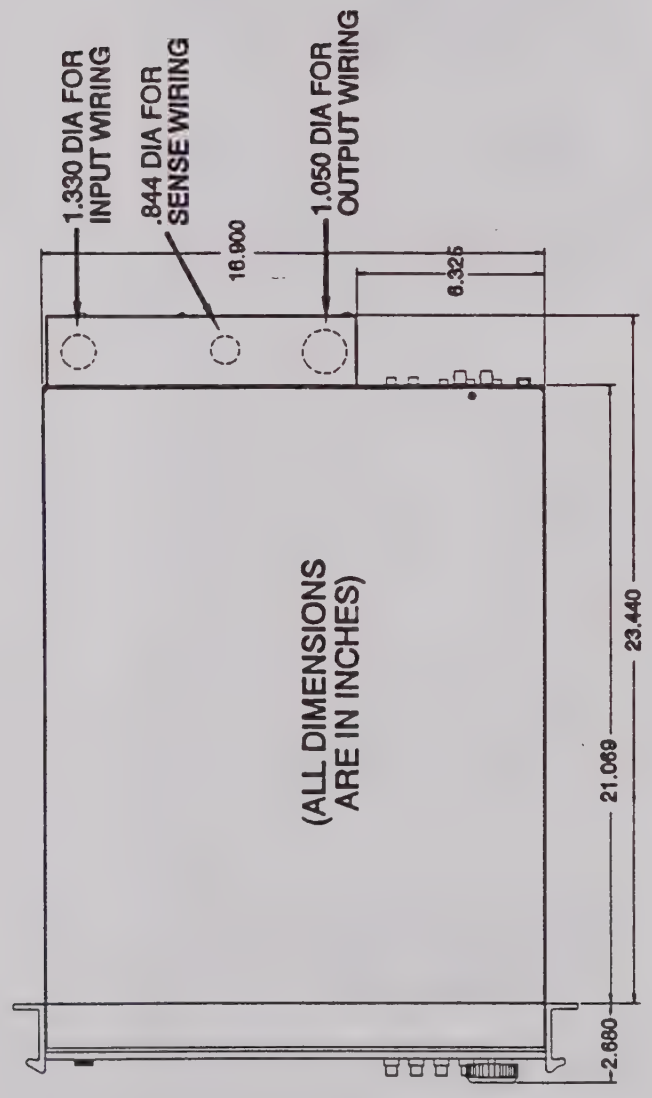


Figure 2-1. SW 5250 (Front View) Mounting Dimensions



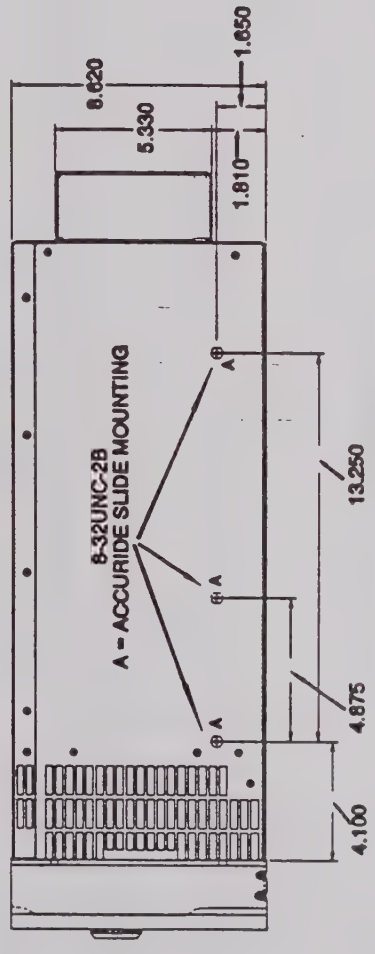


Figure 2-2. SW 5250 (Top and Side View) Mounting Dimensions

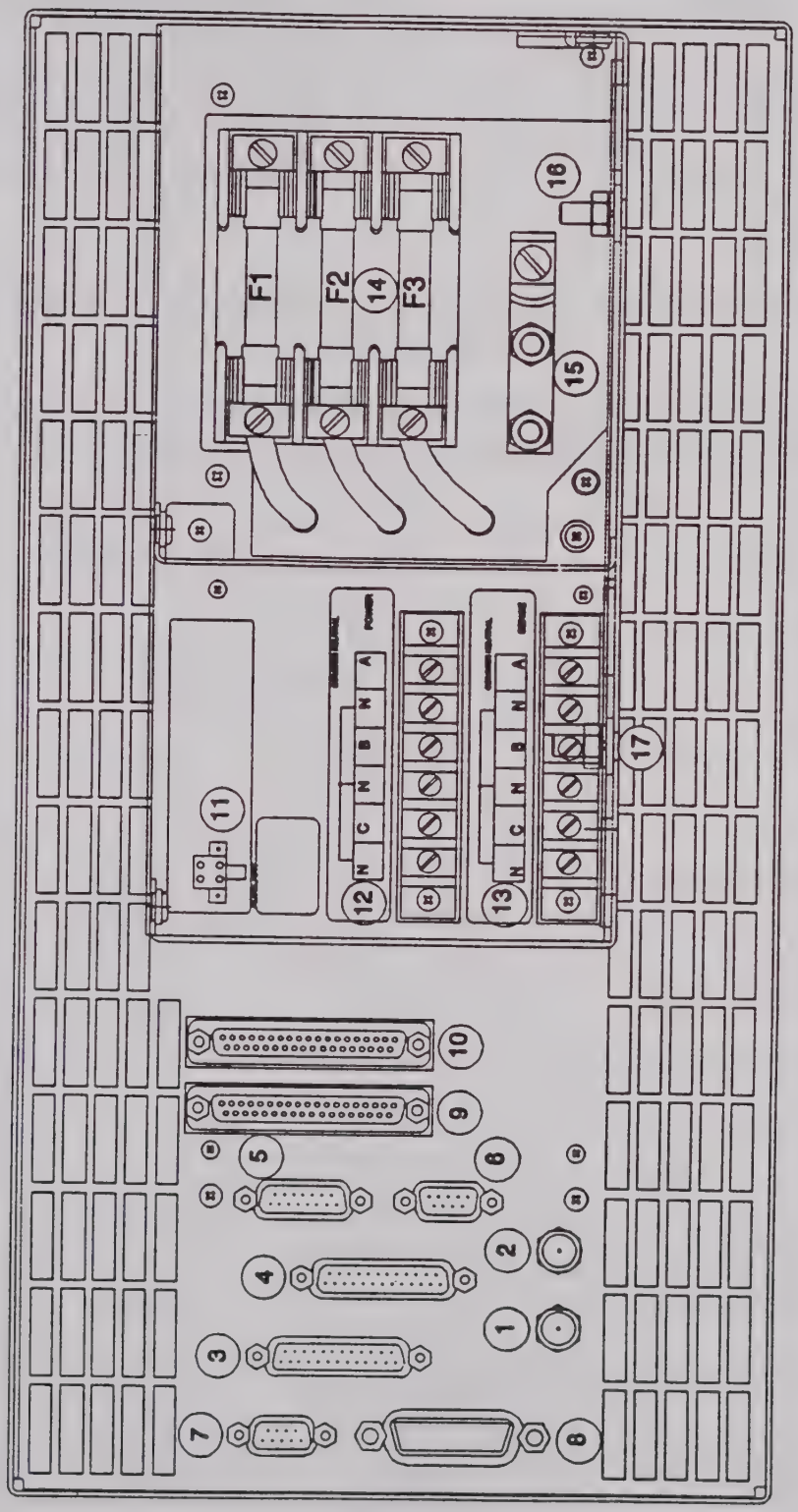


Figure 2-3. SW 5250 Rear Panel

2.7 INPUT/OUTPUT CONNECTORS

Table 2–2 provides a listing of the SW 5250 input and output connectors and other data. Tables 2–3 through 2–7 provide specific pinout information.

NOTE

The RS232, SLAVE IN, SLAVE OUT AND AUX OUT connectors (Figure 2–3, Items 6, 9, 10, and 11, respectively) are Elgar proprietary. Thus, the pinouts will not be provided.

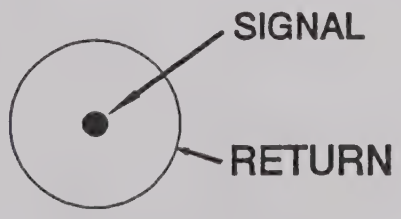
Table 2–2. SW 5250 Input/Output Connectors and Other Data (Refer to Figure 2–3)

Item #	Name	Type	Manufacturer and Part Number
1	SYNC OUT	BNC	KINGS, PN KC–79–179
2	CLOCK & LOCK	BNC	KINGS, PN KC–79–179
3	VXI A	25 POS SUB–D FEMALE (Gold Contacts)	AMP, PN 747052–2
4	VXI B	25 POS SUB–D FEMALE (Gold Contacts)	AMP, PN 747052–2
5	EXT IN ±7.5V MAX	15 POS SUB–D FEMALE (Gold Contacts)	AMP, PN 747052–3
6	RS232	9 POS SUB–D MALE (Gold Contacts)	AMP, PN 747043–4
7	DFI	9 POS SUB–D FEMALE (Gold Contacts)	AMP, PN 747052–4
8	IEEE 488.2	25 POS FEMALE (Gold Contacts)	AMP, PN 554434–1
9	SLAVE IN	37 POS SUB–D FEMALE	ITT CANNON, PN ADC37SOL2
10	SLAVE OUT	37 POS SUB–D FEMALE	ITT CANNON, PN ADC37SOL2
11	AUX OUT	4 POS MINIFIT JR	MOLEX, 39–29–9045

Item #	Name	Type	Manufacturer and Part Number
12	OUTPUT POWER TERMINAL BARRIER	6 POS (#6 HDW)	MAGNUM, PN A304106–07–CA–MP8
13	REMOTE SENSE TERMINAL BARRIER	6 POS (#6 HDW)	MAGNUM, PN A304106–07–CA–MP8
14	FUSE F1	300V 50A SLOW BLOW	BUSSMAN, G30060–3CR
	FUSE F2	300V 50A SLOW BLOW	BUSSMAN, G30060–3CR
	FUSE F3	300V 50A SLOW BLOW	BUSSMAN, G30060–3CR
15	INPUT, NEUTRAL LUG, SINGLE BARREL	90A, 8AWG–2AWG	PANDUIT, PN C070–14–Q
16	SAFETY GROUND	STUD	#1/4–20 X .75 LG
17	CHASSIS GROUND	STUD	#1/4–20 X .75 LG

2.7.1 BNC Connectors (Figure 2–3, Items 1 and 2)

The figure below illustrates the signal and return connections.



2.7.2 VXI A
(Figure 2–3, Item 3)

Refer to Table 2–3.

Table 2–3. VXI A Connector Pinout

Pin #	Mnemonic	Level
1	TX IN +	RS–422
2	TX IN –	RS–422
3	RX IN +	RS–422
4	RX IN –	RS–422

2.7.3 VXI B
(Figure 2–3, Item 4)

Refer to Table 2–4.

Table 2–4. VXI B Connector Pinout

Pin #	Mnemonic	Level
1	TX OUT +	RS–422
2	TX OUT –	RS–422
3	RX OUT +	RS–422
4	RX OUT –	RS–422

2.7.4 EXT IN (External Input) (Figure 2–3, Item 5)

Refer to Table 2–5.

Table 2–5. EXT IN Connector Pinout

Pin #	Mnemonic	Level
1	SHIELD	CHASSIS
2	SHIELD	CHASSIS
3	SHIELD	CHASSIS
4	SHIELD	CHASSIS
5	SHIELD	CHASSIS
6 through 9	Not Used	Not Used
10	EXT_IN_A	+7.25 Vpeak DC to 5000 Hz, ≥30 kΩ
11	EXT_IN_B	+7.25 Vpeak DC to 5000 Hz, ≥30 kΩ
12	EXT_IN_C	+7.25 Vpeak DC to 5000 Hz, ≥30 kΩ
13	EXT_RETURN	+20 Vpeak WRT CHASSIS GROUND
14 and 15	Not Used	Not Used

2.7.5 DFI (Direct Fault Indicator) (Figure 2–3, Item 7)

The DFI connector on the rear panel has both input and output functionality.

The DFI Output Relay indicates a fault has occurred on the SW. It is a SPST reed relay with rear panel connections to the normally closed output contacts. When the SW is operating the relay is energized so that the contacts are open. When a fault occurs, or if the unit should lose power, the relay closes to indicate a fault has occurred.

The DFI Input Signal is used to command the SW to open the Output relay, and close the DFI relay. It is a TTL–compatible input with a 1 kΩ input impedance, a 10 kΩ pullup to +5 VDC, and clamping diodes to _5 VDC and ground. A signal with a negative going edge from +5 VDC to ground will trigger the DFI response.

Refer to Table 2–6.

Table 2–6. DFI Connector Pinout

Pin #	Mnemonic	Level
1	DFI RLY COMM	------
2	Not Used	------
3	DFI IN +	TTL (10 kΩ input impedance)
4 and 5	Not Used	------
6	DFI RLY N.O.	------
7	Not Used	------
8	DFI IN RTN	TTL
9	IEEE 488.2	SIGNAL GND

2.7.6 IEEE 488.2 (Figure 2–3, Item 8)

Refer to Table 2–7.

Table 2–7. IEEE 488.2 Connector Pinout

Pin #	Mnemonic	Pin #	Mnemonic	Pin #	Mnemonic
1	DIO1	9	IFC	17	REN
2	DIO2	10	SRQ	18	GND (TW PAIR W/DAV)
3	DIO3	11	ATN	19	GND (TW PAIR W/NRFD)
4	DIO4	12	SHIELD	20	GND (TW PAIR W/NDAC)
5	EOI	13	DIO5	21	GND (TW PAIR W/IFC)
6	DAV	14	DIO6	22	GND (TW PAIR W/SRQ)
7	NRFD	15	DIO7	23	GND (TW PAIR W/ATN)
8	NDAC	16	DIO8	24	SIGNAL GROUND

2.7.7 Grounding

The three waveform outputs (TRIGGER OUT, CLOCK & LOCK, and SYNC OUT) share the same ground. **This ground should not exceed 30V from chassis ground.** It is recommended that this ground is connected to the chassis if possible.

DFI and IEEE 488.2 share the same signal ground.

2.8 INPUT POWER REQUIREMENTS

Input power is connected to the SW 5250 (also the SW 3500 and SW 1750) via the rear panel connectors. See paragraph 2.8.4 for SW 3500 and SW 1750 differences. Also see Table 2–8 for input current values.

2.8.1 187 to 264 VRMS 3–Phase Operation

Connect the input wires to the phase A, B, and C input fuse terminals (no Neutral is required). **Ensure that the chassis safety ground is also connected.** Use cables with ratings equal to or greater than the current rating listed on the unit (see Section 2.9). Any phase sequence of wiring can be used.

2.8.2 342 to 457 VRMS 3–Phase Operation

It is essential that the Neutral connection is present when using the unit. An external breaker is recommended for the 3–phase voltages. Do not pass Neutral through the breaker. Only units factory set at this voltage will operate at this voltage.

CAUTION

Neutral must not be broken by an external switch. Severe damage to the unit may occur if Neutral is broken and phase voltage is present.

Connect the input wires to phases A, B, C and Neutral. **Ensure that the chassis safety ground is also connected.** Use cables with ratings equal to or greater than the current rating listed on the unit (see Section 2.9).

2.8.3 Connection to the Load

The Model SW 5250 can power 1–phase, 2–phase and 3–phase loads. Local or remote sensing can be used; if no sense lines are connected, the unit automatically reverts to local sense. Outputs may be directly paralleled for greater power. If the outputs are paralleled it is important to program the unit to the parallel mode before shorting the outputs together (refer to Figure 2–4). Outputs cannot be placed in series since the Neutral is common. However, by programming two phases 180° apart, double voltage, single phase is achieved.

Any phase sequence of wiring can be used.

The sense Neutral is also common. Thus, it is important not to mis–wire the sense wires (refer to Figure 2–5. If remote sense is used:

- Sense A is connected to Power A;
- Sense B is connected to Power B;
- Sense C is connected to Power C;
- Neutral Sense is connected to Neutral Power.

It is important that the Neutral not be >20V away from the chassis potential since the unit will shut down if this voltage is exceeded. It is recommended that output Neutral be connected to chassis ground.

If a transformer or inductive load is present, the unit should be programmed to AC. This prevents small amounts of DC being generated which may saturate the magnetics.

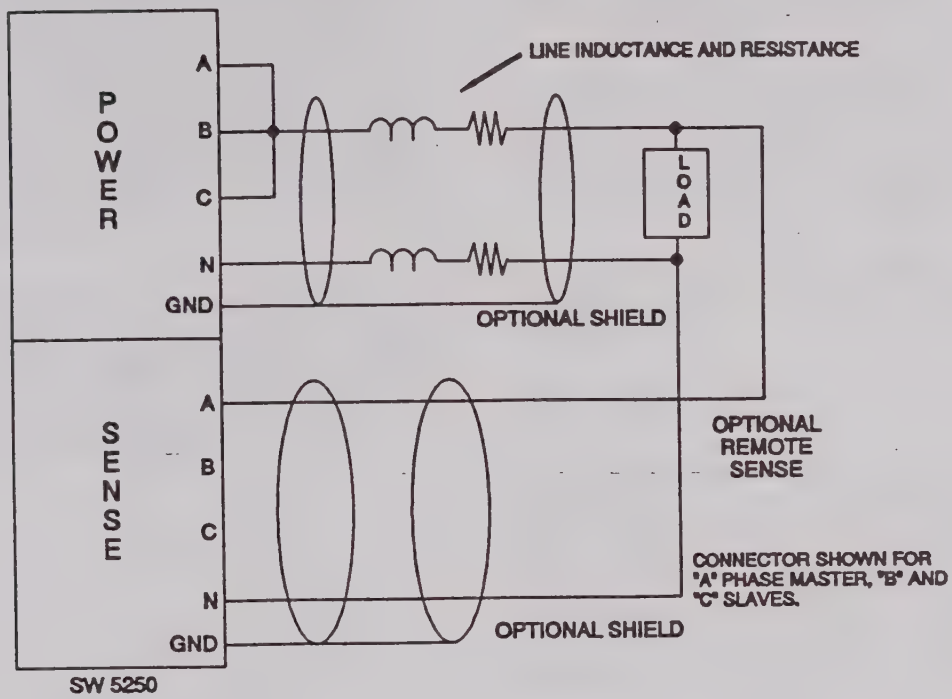


Figure 2–4. Parallel Connections

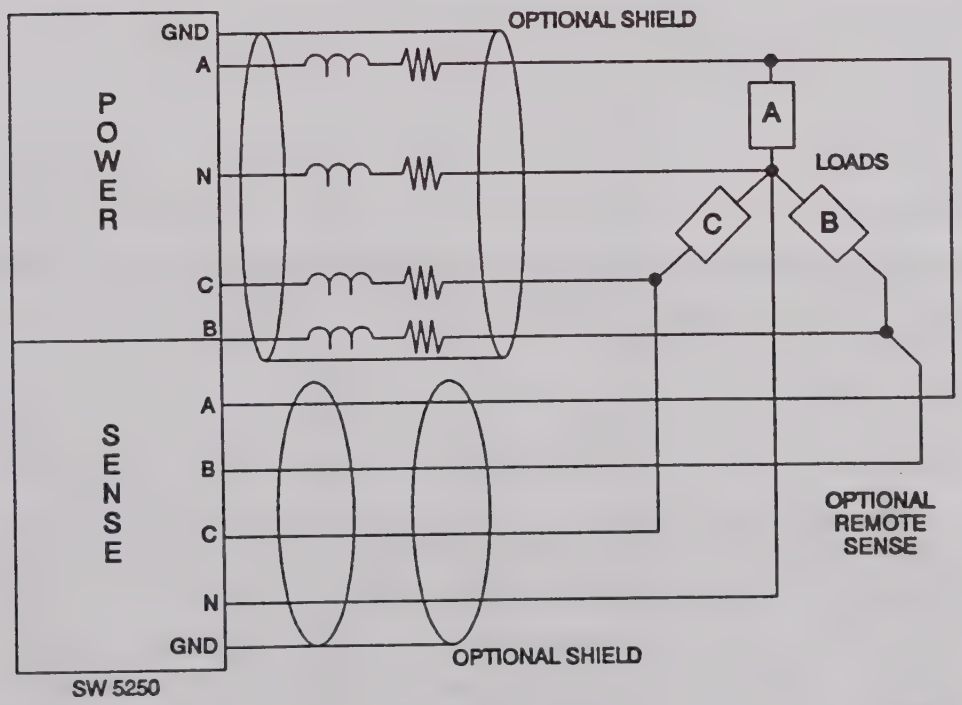


Figure 2–5. Sense Lead Connections for 3–Phase Output

Sense leads should be shielded and the shield connected to the chassis to prevent noise pickup (or radiation to sensitive circuits in the vicinity). The power leads may also require shielding to minimize radiation to other circuits. Again, the shield should be connected to chassis ground.

Due to the high voltages present, 312 VRMS line–to–neutral and 437 VRMS line–to–line cables rated to these voltages must be used for both the Power and Sense leads.

2.8.4 SW 3500 and SW 1750 Connections

The Model SW 3500 has phase A and phase B present; phase C is an open circuit. Make connections as for the SW 5250 but with phase C missing.

The Model SW 1750 has only phase A present; phases B and C are open circuits.

2.8.5 Wiring of Unit

Due to the high voltages and frequencies involved, it is recommended that all input and output wiring is protected with flexible conduit. Holes for this purpose are made in the terminal box (see Figure 2–2). All wiring must meet local standards for safety.

Table 2–8. Input Currents

Model SW 5250			
		Line	Neutral
PFC	USA	30A	Not Required
PFC	EUR	16A	16A
RECT	USA	45A	Not Required
RECT	EUR	45A	75A
Model SW 3500			
		Line	Neutral
PFC	USA	30A	Not Required
PFC	EUR	16A	16A
RECT	USA	30A	Not Required
RECT	EUR	30A	50A
Model SW 1750			
		Line	Neutral
PFC	USA	16A	Not Required
PFC	EUR	16A	16A
RECT	USA	15A	Not Required
RECT	USA	15A	25A

2.9 WIRE GAUGE SELECTION

The following guidelines assist in determining the optimum cable specification for the user's power applications. These guidelines are equally applicable to both DC and low frequency AC (up to 450 Hz) power cabling. The same engineering rules apply whether going into or out of an electrical device. Thus, this guide applies equally to the input cable and output cable for this ELGAR instrument and application loads.

Power cables must be able to safely carry maximum load current without overheating or causing insulation destruction. It is important to everyday performance to minimize IR (voltage drop) loss within the cable. These losses have a direct effect on the quality of power delivered to and from instruments and corresponding loads.

When specifying wire gauge, the operating temperature needs to be considered. Wire gauge current capability and insulation performance drops with the increased temperature developed within a cable bundle and with increased environmental temperature. Thus, short cables with generously derated gauge and insulation properties are recommended for power source applications.

Avoid using published commercial utility wiring codes. These codes are designed for the internal wiring of homes and buildings and accommodate the safety factors of wiring loss, heat, breakdown insulation, aging, etc. However, these codes consider that up to 5% voltage drop is acceptable.

Such a loss directly detracts from the quality performance specifications of this ELGAR instrument. Frequently, these codes do not consider bundles of wire within a cable arrangement.

In high performance applications, as in motor start–up and associated inrush/ transient currents, additional consideration is required. The cable wire gauge must consider peak voltages and currents which may be up to ten times the average values. An underrated wire gauge adds losses which alter the inrush characteristics of the application and thus the expected performance.

Table 2–9 identifies popular ratings for DC and AC power source cable wire gauges.

Table 2–9. Recommended Wire Gauge Selection Guide

Column 1	Column 2	Column 3	Column 4
Size (AWG)	Amperes (Maximum)	Ohms/100 Feet (One Way)	IR Drop/100 Feet (Col. 2 X Col. 3)
14	15	0.257	3.85
12	20	0.162	3.24
10	30	0.102	3.06
8	40	0.064	2.56
6	55	0.043	2.36
4	70	0.025	1.75
2	95	0.015	1.42
1/0	125	0.010	1.25
3/0	165	0.006	1.04

The following notes apply to Table 2–9 and to the power cable definition:

1. The above figures are based upon insulated copper conductors at 25°C (77°F), two current carrying conductors in the cable plus a safety (chassis) ground.

   Columns 3 and 4 refer to "one way" ohms and IR drop of current carrying conductors (e.g., a 50–foot cable contains 100 feet of current carrying conductor).

2. Determine which wire gauge for the application by knowing the expected peak load current (I_{peak}), the maximum tolerated voltage loss (V_{loss}) within the cable, and the one way cable length.

   The formula below determines which ohms/100 feet entry is required from Column 3. Read the corresponding wire gauge from Column 1.

   (Column 3 value) =

   $V_{loss}/[I_{peak} \times 0.02 \times (\text{cable length})]$

   Where:

   Column 3 value =

   Entry of the table above.

   Cable length =

   One way cable length in feet.

   V_{loss} =

   Maximum loss, in volts, permitted within cable.

Special case: Should the V_{loss} requirement be very loose, I_{peak} may exceed the maximum amperes (Column 2). In this case, the correct wire gauge is selected directly from the first two columns of the table.

Example:

A 20 ampere (I_{peak}) circuit which may have a maximum 0.5 volt drop (V_{loss}) along its 15–foot cable (one way cable length) requires (by formula) a Column 3 resistance value of 0.083. This corresponds to wire gauge size 8 AWG.

If the cable length was 10 feet, the Column 3 value would be 0.125 and the corresponding wire gauge would be 10 AWG.

3. Aluminum wire is not recommended due to soft metal migration at the terminals which may cause long term (on the order of years) poor connections and oxidation. If used, increase the wire gauge by two sizes (e.g., specify 10 gauge aluminum instead of 14 gauge aluminum).

4. Derate the above wire gauge (use a heavier gauge) for higher environmental temperatures since conductor resistance increases with temperature.

Temperature Degrees		Current Capability
C	F	
40	104	80%

5. Derate the above wire gauge (use a heavier gauge) for an increased number of current carrying conductors. This offsets the thermal rise of bundled conductors.

Number of Conductors	Current Capability
3 to 6	80%
Above 6	70%

6. The preferred insulation material is application dependent. Elgar's recommendation is any flame retardant, heat resistant, moisture resistant thermoplastic insulation rated to a nominal 75°C (167°F). Voltage breakdown must exceed the combined effects of:

- The rated output voltage;
- Transient voltages induced onto the conductors from any source;
- The differential voltage to other nearby conductors; and,
- Safety margins to accommodate degradations due to age, mechanical abrasion and insulation migration caused by bending and temperature.

7. As frequency increases, the magnetic field of the current carrying conductors becomes more significant in terms of adverse coupling to adjacent electrical circuits. Use twisted pairs to help cancel these effects. Shielded twisted pairs are even better. Avoid close coupling with nearby cables by using separate cable runs for high power and low power cables.

8. The above general values and recommendations should be reviewed, modified and amended, as necessary, for each application. Cables should be marked with appropriate safety WARNING decals as hazardous voltages may be present.

SECTION III

OPERATION

3.1 INTRODUCTION

The controls and display for the Model SW 5250 are easily understood after a brief overview.

3.2 FRONT PANEL CONTROLS

Refer to Figure 3–1.

3.2.1 Power On/Off Switch

The power on/off switch is located in the lower left of the front panel. Pressing the top portion of the switch turns power on; pressing the bottom portion of the switch turns power off.

When power is turned on, the SW 5250 goes through the power up cycle. This cycle may last between 30 seconds and five minutes, depending on the amount of software that needs to be loaded and conditioned. The display will indicate the Elgar logo during the turn on cycle.

3.2.2 Contrast Keys

The **Contrast** keys, located below the knob, are used to adjust the contrast of the display. Pressing the left key decreases the contrast while pressing the right key increases the contrast. The appropriate key should be pressed and held until the display is at the desired contrast level.

3.2.3 Keypad

The 12–key keypad is used for entering various numeric values (0 through 9), a decimal point (when required), and to change the polarity of the selection via the +/– key. For example, to enter an amplitude value of "–139.2," the user enters 1, 3, 9, decimal point, 2; presses the +/– key to change the polarity; then presses the Enter key to accept the value.

3.2.4 Enter Key

Pressing the **Enter** key allows the user to:

- Go to the next menu level on the LCD display;
- Enter the incr./dec. mode using the knob or arrow keys;
- Accept a number after a numeric entry via the keypad and/or knob; and
- Accept a name in Text Mode entry.

3.2.5 Menu Key

Pressing the **Menu** key allows the user to go to the previous menu level on the LCD display, or to abort the modification of an edit field.

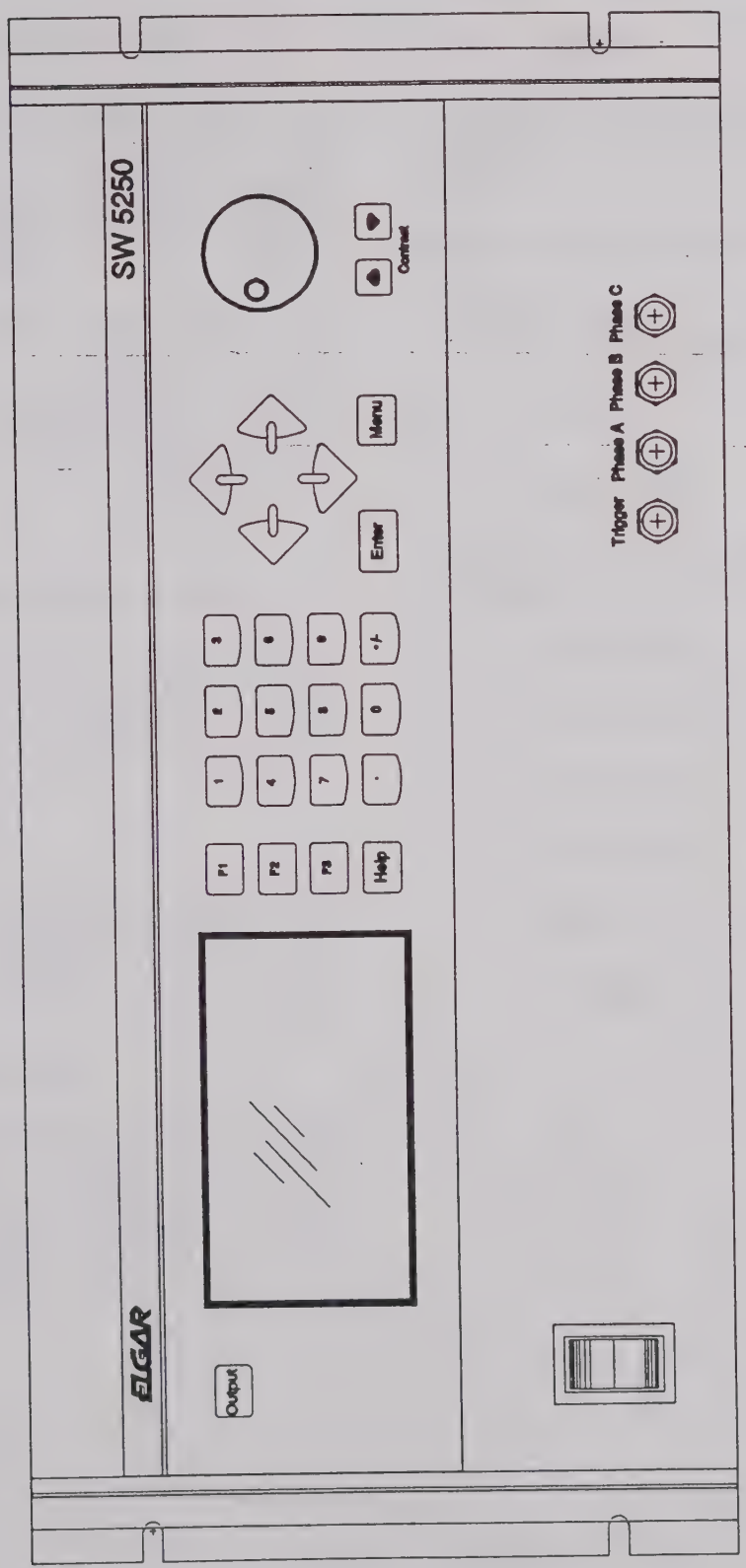


Figure 3-1. SW 5250 Front Panel Controls

3.2.6 Arrow Cursor Keys

The **Up and Down Arrow Cursor Keys** are used to move between menu selections on the current page displayed on the LCD display and to increase or decrease values in the incr./dec. mode.

3.2.6.1 Left Arrow Cursor Key

The left Arrow Cursor Key moves the user to the previous menu level (a shortcut for the <Menu> key) and, in the Text Mode or numeric entry, acts as a backspace.

3.2.6.2 Right Arrow Cursor Key

The right Arrow Cursor Key moves the user to the next menu level (a shortcut for the <Enter> key) and, in the Text Mode, accepts the current character.

3.2.7 Knob

The **Knob** is used for data entry and for slewing of voltage and frequency. The knob serves the same function as the up and down arrow keys.

3.2.8 Output Key

The **Output** key opens or closes the output relay. The condition of the output relay is indicated on the LCD display by "OUTPUT [ON]" or "OUTPUT [OFF]" being displayed on the top line.

3.2.9 Help Key

Pressing the **Help** key will display a help screen for the current menu on the display.

3.2.10 Function Keys F1 Through F3

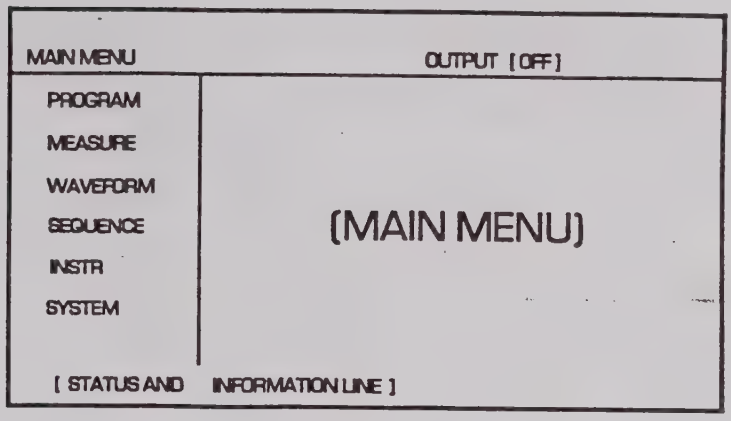
Function depends on the selected menu item and is defined in the Help screens.

3.3 MENUS

3.3.1 MAIN MENU

The **MAIN MENU** consists of the following sub–menus:

- PROGRAM
- MEASURE
- WAVEFORM
- SEQUENCE
- INSTR (INSTRUMENT)
- SYSTEM



MAIN MENU Status and Information Data

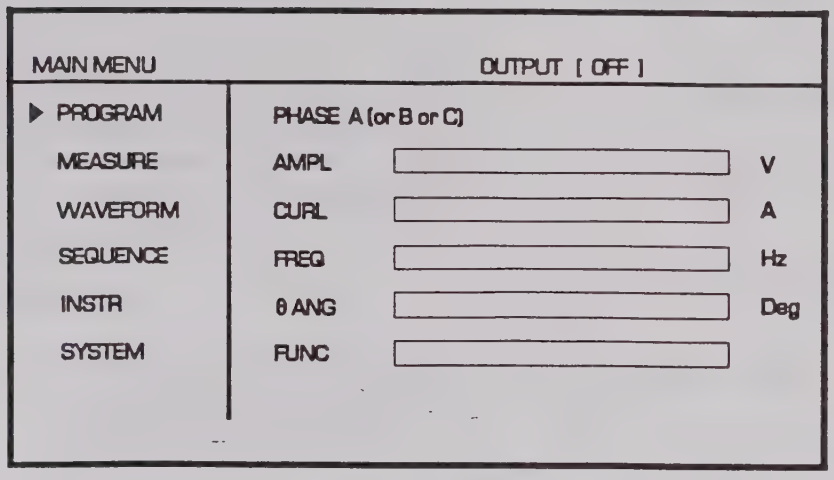
Item	Status and Information Line Readout
PROGRAM	[interactive programming]
MEASURE	[measurement system]
WAVEFORM	[create/edit waveform]
SEQUENCE	[create/edit sequences]
INSTR	[instrument configuration]
SYSTEM	[system configuration]

- Use the **Enter** and **Menu** keys or the **Right** and **Left** arrow keys to move between the menus.
- Use the **Up** and **Down** arrow keys to toggle within a menu.
- When an item is selected by an arrow pointing to it, either type in the data or press the **Enter** key to place a box around the value area. If the latter is done, use the **Up/Down** arrow keys or the knob to select the data to be entered.
- In either case, after the data is input, press the **Enter** key to enter the data.

3.3.2 PROGRAM Menu

The **PROGRAM** menu allows the user to:

- Select a phase.
- Program amplitude (in volts to 0.01V resolution).
- Program current limit, either a value or level (in amps).
- Program frequency (40 to 5000 Hz).
- Program phase offset (the default is 0°, 120°, 240°).
- Select a function to be output on the selected phase.



* - Changing the Frequency of One Phase will Change the Frequency of the Other Two Phases

PROGRAM Menu Status and Information Line Data

Menu Item	Status and Information Line Readout
PHASE A	[<enter> for phase B]
AMPL	[program output RMS/DC voltage]
CURL	[program RMS/DC current limit]
FREQ	[program output frequency] *
θ ANG	[program phase angle offset]
FUNC	[program output waveform] **

* – There is only one frequency setting for all three phases. Changing the frequency of one phase changes the frequency for all phases.

** – To operate the SW 5250 as a DC supply, select the function as "DC+" or "DC–" for positive and negative DC. "AC+DC Coupling" must also be selected from the INSTRUMENT menu.

3.3.2.1 Locking Program Fields

For two– or three–phase systems, individual programming fields of amplitude, current limit, frequency, phase angle, and function may be "locked" so that any change made to phase A will be made to phases B and C.

To lock a field:

1. Move the field select cursor to the field to be locked in the Phase A Program menu.
2. Press the **F1** function key. The "¥" symbol should appear to the right of the field indicating the lock mode is active.

To unlock a field:

1. Move the field select cursor to the field that is locked in the Phase A Program menu.
2. Press the **F1** function key. The "¥" symbol should disappear.

3.3.2.2 Front Panel Store/Recall

The current state of the Program menu (amplitude, current limit, frequency, phase angle, and function) may be saved as a front panel setup for later recall. The Store/Recall Menu can be accessed by pressing **F2** from any Program menu edit field. Setups are stored/recalled as a number from 1 to 50.

To store a setup:

1. Press **F2** from any Program menu edit field.
2. Move the field cursor to "STORE SETUP."
3. Enter a setup number from 1 to 50.

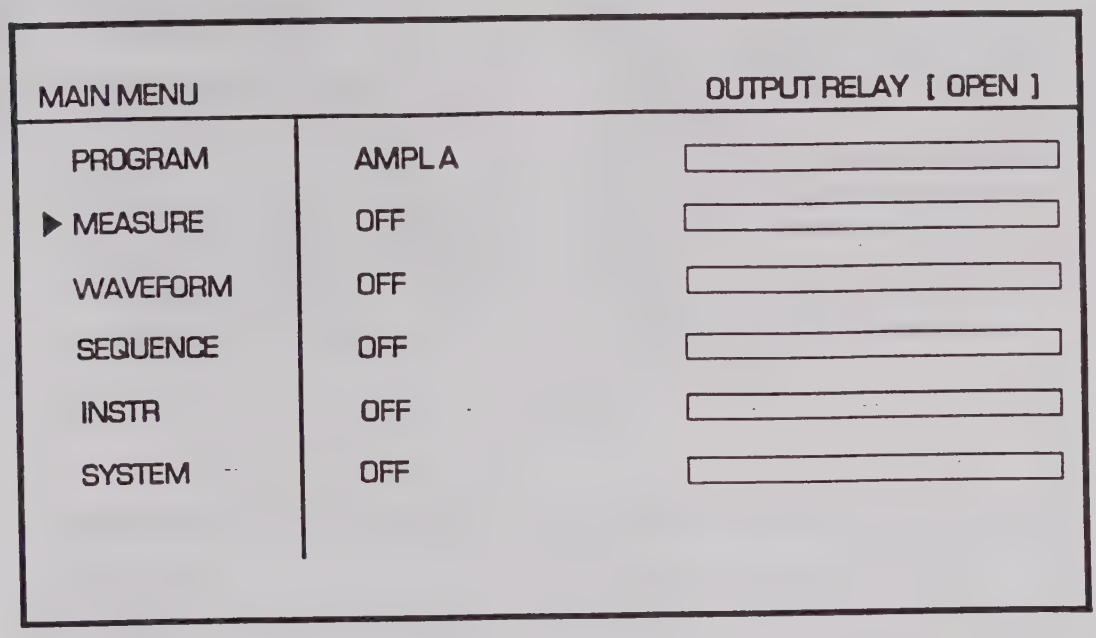
To recall a setup:

1. Press **F2** from any Program menu edit field.
2. Move the field cursor to "RECALL SETUP."
3. Enter the previously stored setup number from 1 to 50.

3.3.3 MEASURE Menu

The **MEASURE** menu allows the user to:

- Select a phase.
- Measure voltage (RMS).
- Measure current (RMS).
- Measure frequency.
- Measure phase angle (referenced to the master).
- Measure power (W).
- Measure apparent power (VA).
- Measure power factor (PF).
- Measure peak current.



The Measure menu contains six display fields that can be set to any of the available measurements.

To set a measurement field:

1. Move the field cursor to one of the six measurement fields.

2. Press <Enter>. A pop-up window will be displayed with the title **SELECT MEASUREMENT**; **OFF** will be selected.

3. Use the up/down arrow keys or the knob to scroll through the list of available measurements.

4. With the desired measurement in the selection window (or OFF to disable a measurement), press <Enter>.

5. The measured value will be displayed in the display field.

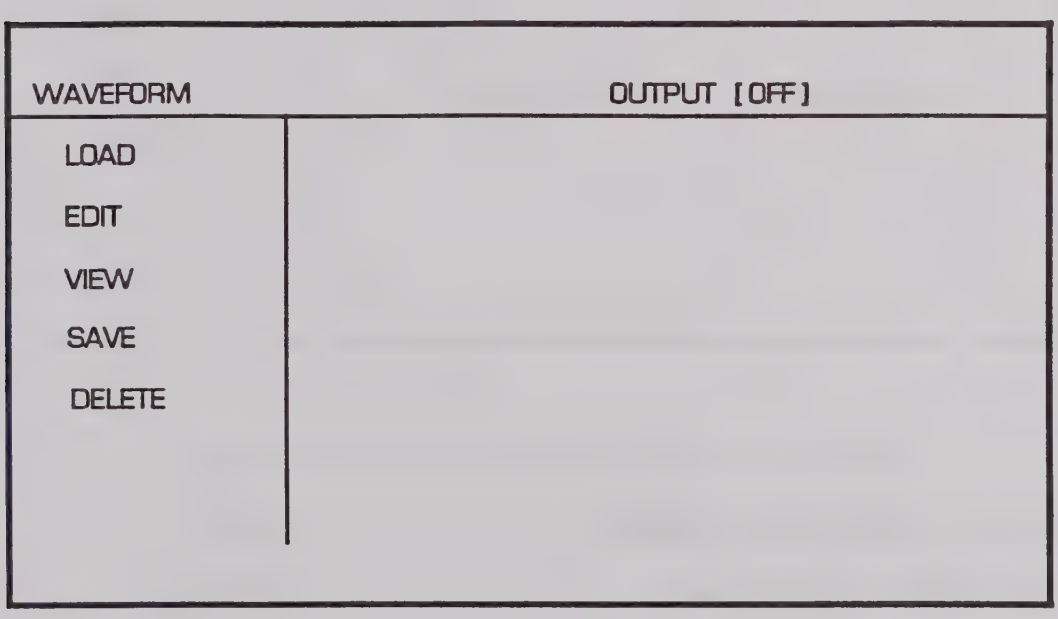
Active measurement fields are continually updated.

3.3.4 WAVEFORM Menu

The **WAVEFORM** menu allows the user to:

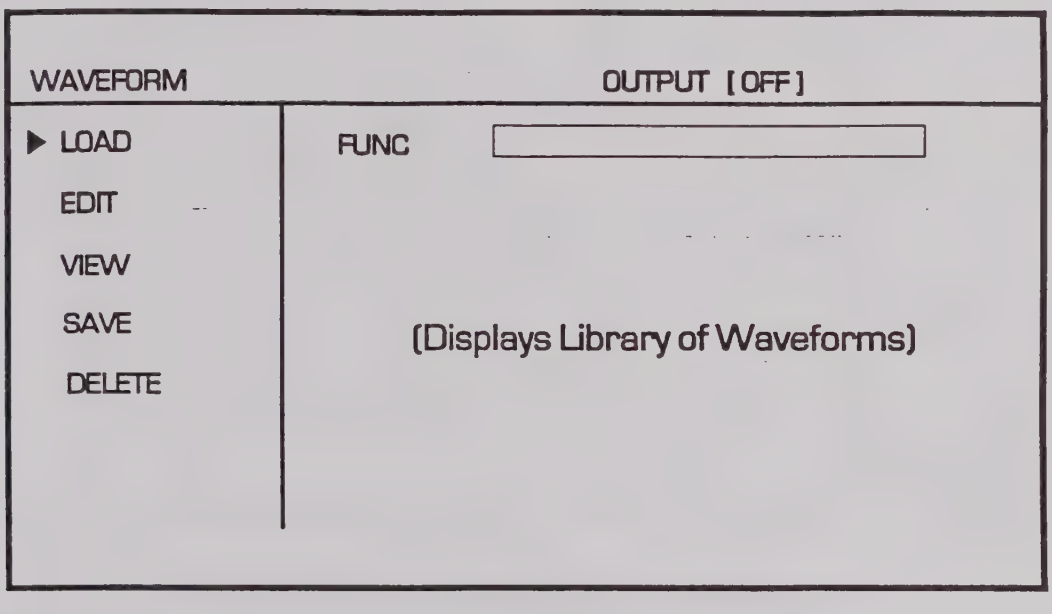
- Perform a variety of actions on waveshapes and waveforms, including the creation of a new waveform based on a waveshape in memory.

The waveshapes and waveforms are limited to spikes, dropouts, sags and surges of existing waveforms in the scratchpad area. This is accomplished by LOADing the existing waveshape into the waveform scratch pad then editing it. The edited waveform may then be viewed, output using the SCRATCH function name in the PROGRAM menu, or saved to the waveform library.



3.3.4.1 LOAD Sub-Menu

The WAVEFORM menu allows the user to **LOAD** an existing waveform from non-volatile memory or EPROM to the scratchpad.

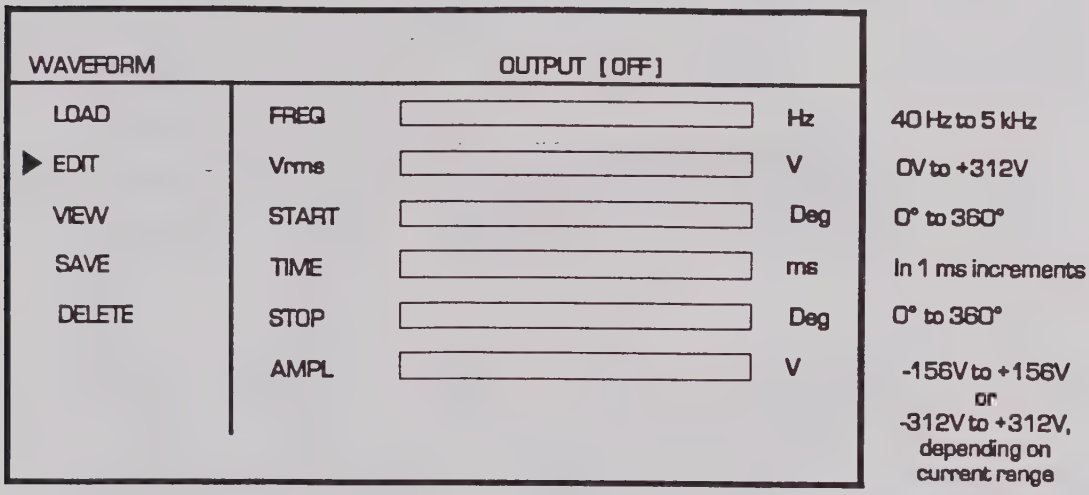


LOAD Sub-Menu Status and Information Line Data

Item	Status and Information Line Readout
LOAD	[load waveform to scratchpad]
FUNC	[<enter> to select waveform]

3.3.4.2 EDIT Sub-Menu

The WAVEFORM menu allows the user to **EDIT** a waveform in the scratchpad.

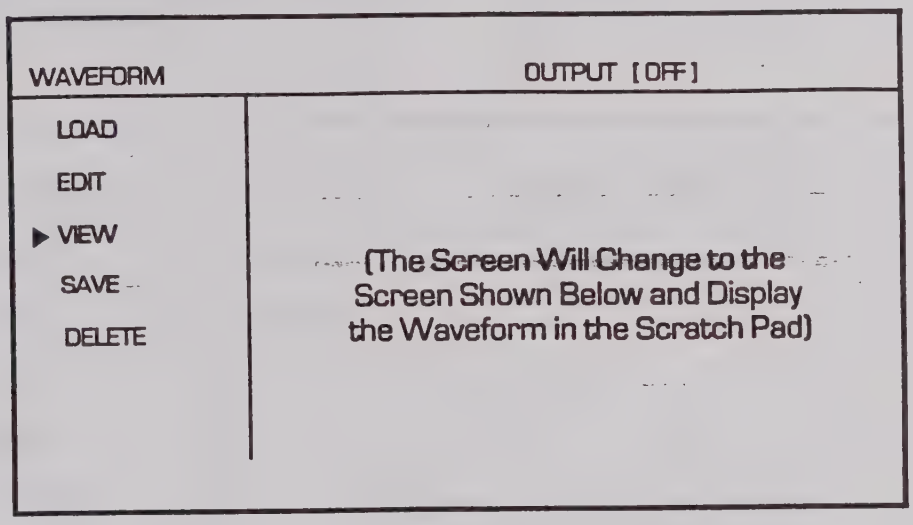


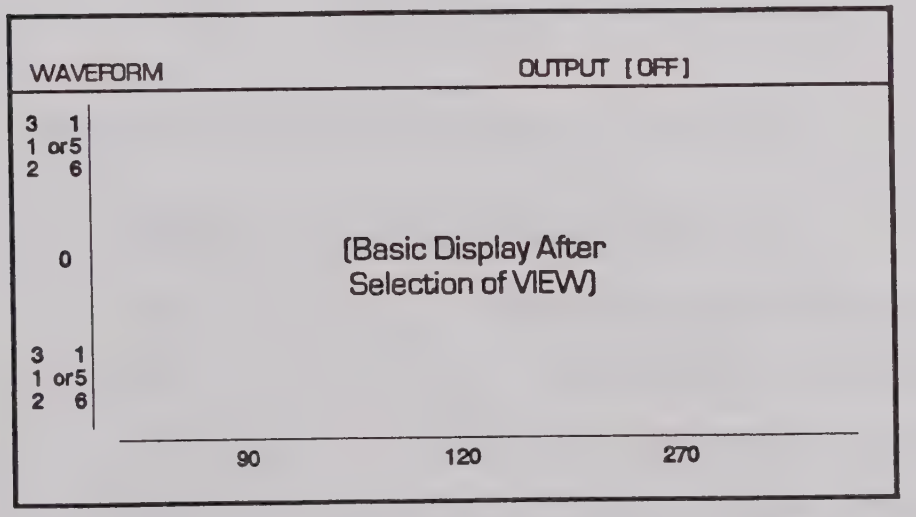
EDIT Sub-Menu Status and Information Line Data

Item	Status and Information Line Readout
EDIT	[edit waveform in scratchpad]
FREQ	[waveform frequency]
Vrms	[output waveform voltage]
START	[starting phase angle]
TIME	[surge/sag duration]
STOP	[ending phase angle]
AMPL	[drop/spike voltage]

3.3.4.3 VIEW Sub–Menu

The WAVEFORM menu allows the user to **VIEW** a waveform:





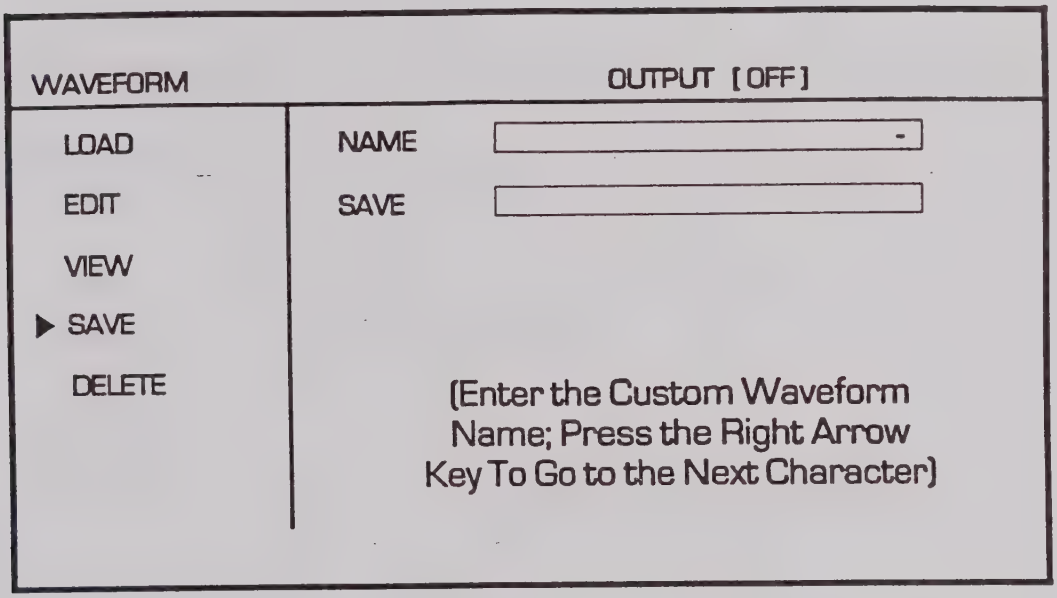
VIEW Sub–Menu Status and Information Line Data

Item	Status and Information Line Readout
VIEW	[display scratchpad]

3.3.4.4 SAVE Sub–Menu

The WAVEFORM menu allows the user to **SAVE** a new waveform from the scratchpad, with a user–defined name, to non–volatile memory.

- First, name the waveform.
- Second, go to SAVE and press <Enter> to save.



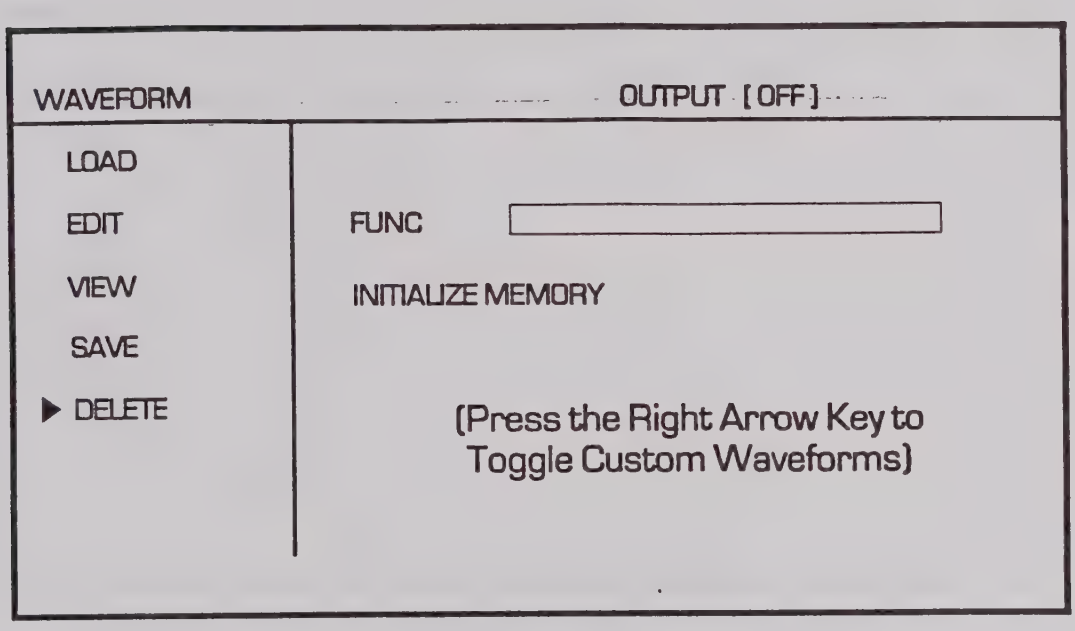
SAVE Menu Status and Information Line Data

Item	Status and Information Line Readout
SAVE	[save waveform in scratchpad]
NAME	[–> = next char, <– = backsp]
SAVE	[save waveform to library]

3.3.4.5 DELETE Sub-Menu

The WAVEFORM menu allows the user to **DELETE** a waveform stored in non-volatile memory.

INITIALIZE MEMORY – This will reset the waveform library to the factory settings. All factory waveforms will be restored and all user waveforms stored in non-volatile RAM will be erased. The user must cycle power to the unit after this function for the changes to take effect.



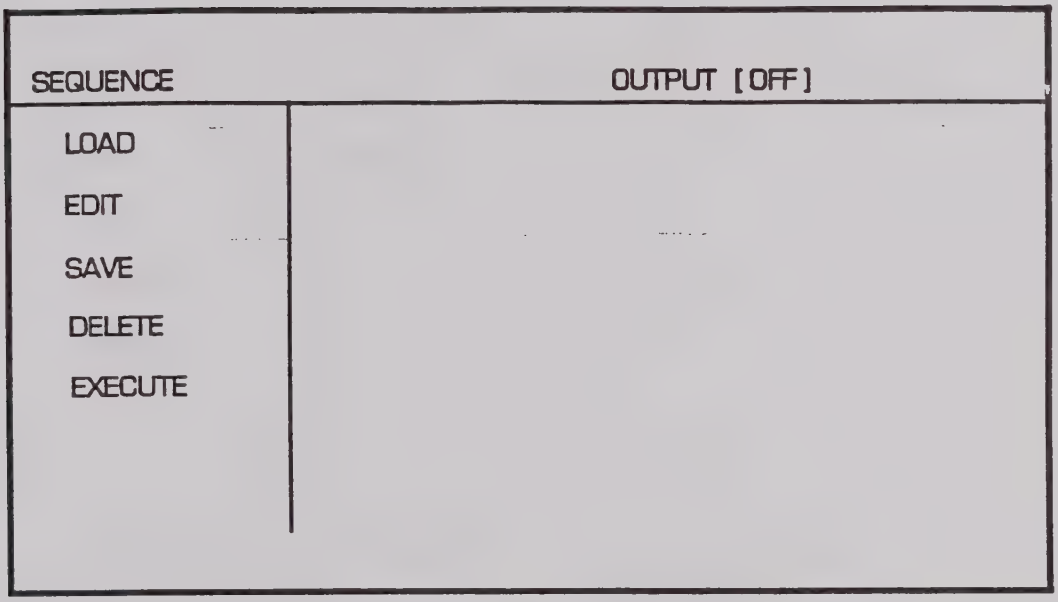
DELETE Sub-Menu Status and Information Line Data

Item	Status and Information Line Readout
DELETE	[delete stored waveform]
FUNC	[<enter> to select waveform]

NOTE: If the User attempts to delete a waveform in ROM, the message "ERROR – STANDARD WAVEFORM" will flash on momentarily.

3.3.5 SEQUENCE Menu

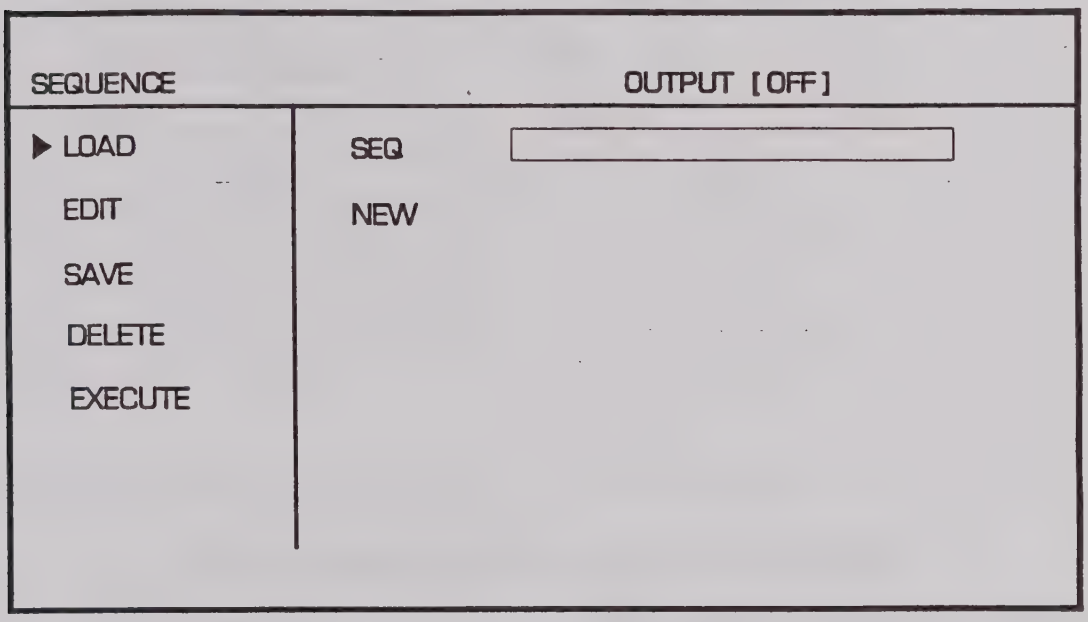
The **SEQUENCE** menu allows the user to create a **NEW** sequence.



3.3.5.1 LOAD Sub–Menu

The SEQUENCE menu allows the user to **LOAD** an existing sequence from non–volatile memory or EPROM to the scratchpad.

NEW – Will erase all segments in the SEQUENCE scratchpad.



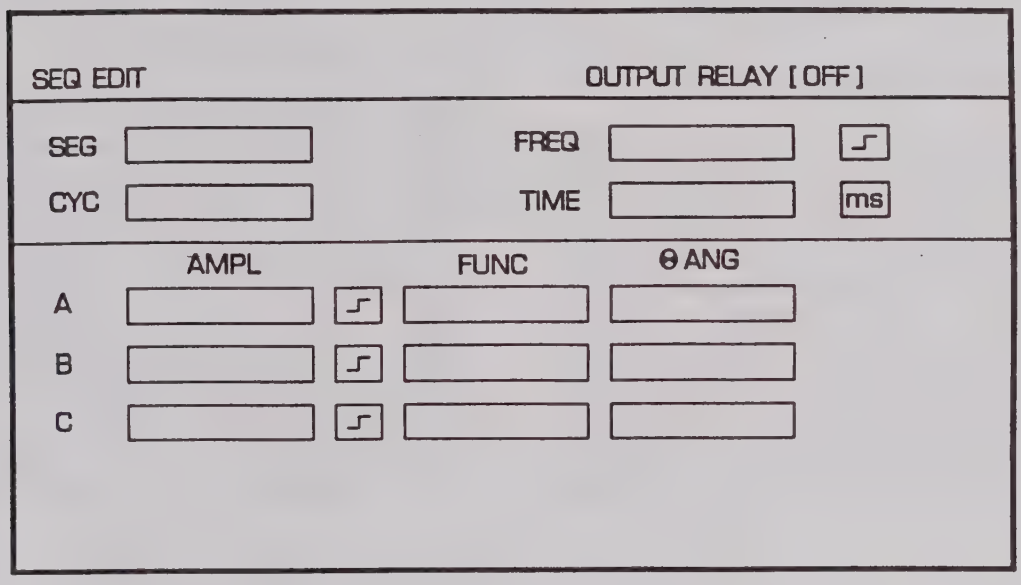
LOAD Sub–Menu Status and Information Line Data

Item	Status and Information Line Readout
LOAD	[load stored sequence]
SEQ	[load sequence to scratchpad]

3.3.5.2 EDIT Sub-Menu

The SEQUENCE menu allows the user to **EDIT** a sequence in the scratchpad.

Frequency or amplitude can be ramped over the segment duration.



EDIT Sub-Menu Status and Information Line Data

Item	Status and Information Line Readout
EDIT	
SEG	[edit sequence in scratchpad]
CYC	[select cycles]
FREQ	[output frequency in Hz]
TIME	[segment execution time]
AMPL	[output voltage in volts]
FUNC	[output waveform]
Θ ANG	[phase angle in degrees]

The function keys **F1 – F3** are required to create and edit sequences. The function keys are dependent on the field selection cursor position and are defined as follows:

- **The "SEG" Edit Field**

The **SEG** edit field is used to move through the segment list and accept integer values from 0 to 999. Since Sequence is made up of a continuous list of segments, segments must be created in sequential order. When the Sequence scratchpad is initialized, only a single segment is available for editing. Trying to access segments other than segment 0 will result in an end of sequence error message. The function keys are used to insert, delete or copy segments:

F1 Inserts a new segment in the position immediately following the current segment. The new segment number will be one greater than the currently displayed segment. The Segment edit field will be automatically updated to display the newly created segment.

F2 Deletes the currently displayed segment.

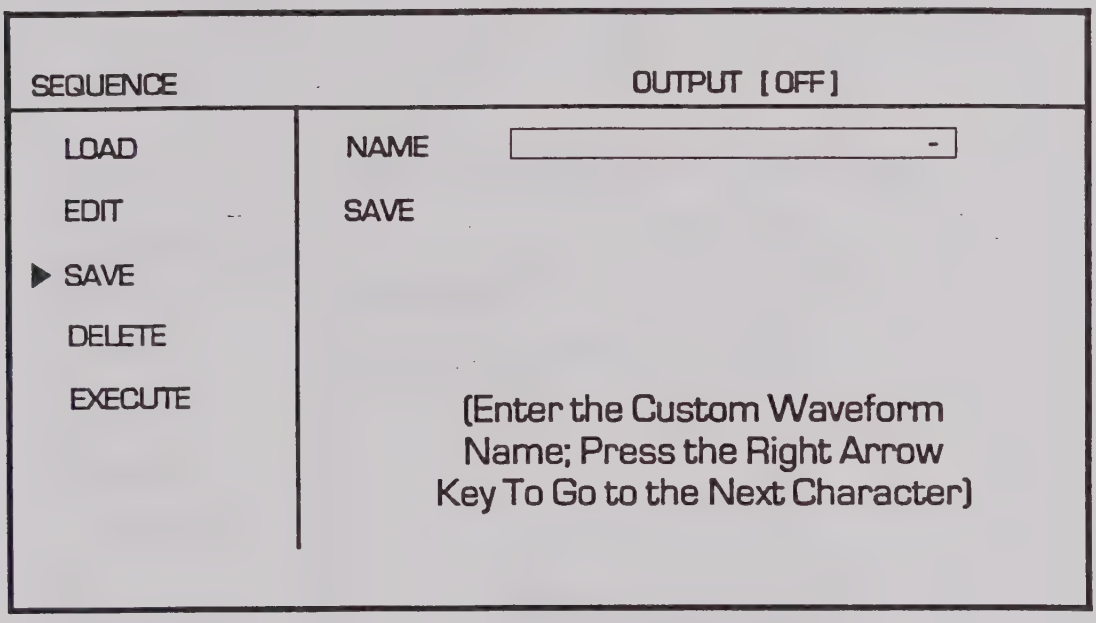
F3 Copies the previous segment information to the currently displayed segment.

- **The "CYCLES" Edit Field**

When the field select pointer is at the CYCLES field, pressing **F1** will toggle the SYNC SELECT symbol "*". This is a flag used in conjunction with the SYNC field of the Sequence Execute menu; if SYNC is set to **SELECT SEG**, only those segments that are enabled will generate a sync signal at the front panel BNC connector. If SYNC is set to **EVERY SEG**, every signal will generate a sync signal.

3.3.5.3 SAVE Sub–Menu

The SEQUENCE menu allows the user to **SAVE** a new sequence from the scratchpad, with a user–defined name, to non–volatile memory.



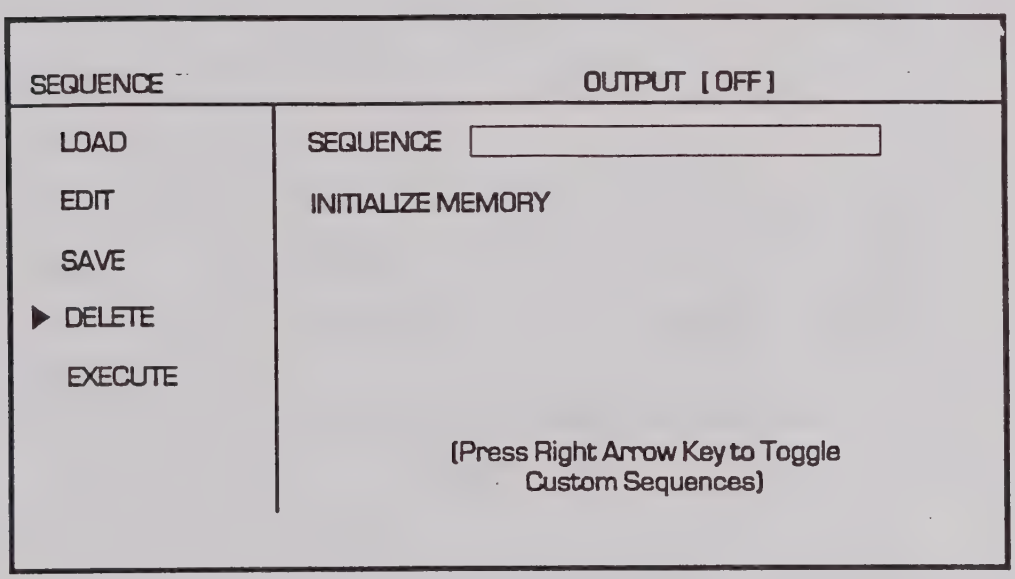
SAVE Sub–Menu Status and Information Line Data

Item	Status and Information Line Readout
SAVE	[save sequence to library]
NAME	[store sequence in library]
SAVE	(blank)

3.3.5.4 DELETE Sub–Menu

The SEQUENCE menu allows the user to **DELETE** a sequence stored in non–volatile memory.

INITIALIZE MEMORY – This will reset the sequence library to the factory settings. All factory sequences will be restored and all user sequences stored in non–volatile RAM will be erased. The user must cycle power to the unit after this function for the changes to take effect.



DELETE Sub–Menu Status and Information Line Data

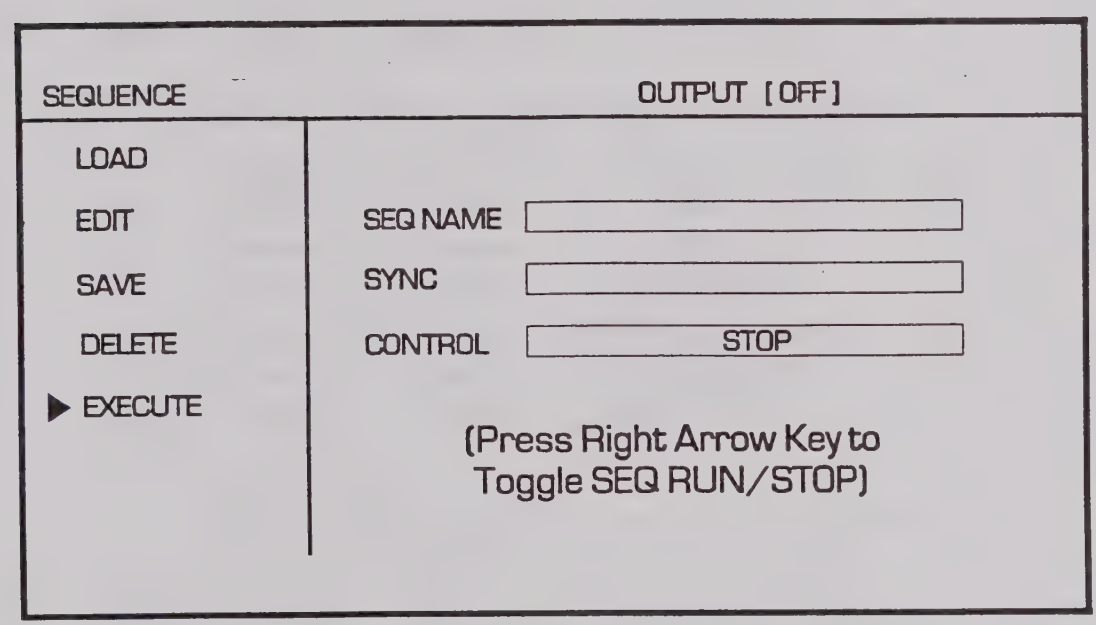
Item	Status and Information Line Readout
DELETE	[delete stored sequence]
SEQUENCE	[delete stored sequence]

3.3.5.5 EXECUTE Sub-Menu

The SEQUENCE menu allows the user to:

- Select a sequence from the sequence library.
- Start (**EXECUTE**) a sequence.

The **SYNC** field can be set to "EVERY SEGMENT" OR "SELECT SEG" (selected segments) and controls the trigger signal at the front panel BNC connector.



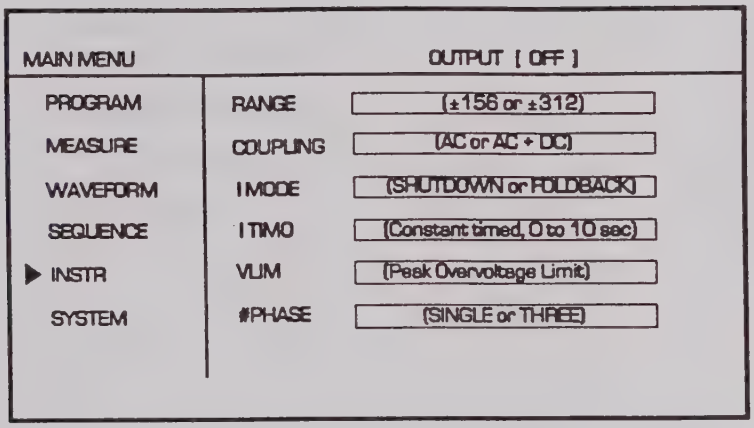
EXECUTE Sub-Menu Status and Information Line Data

Item	Status and Information Line Readout
EXECUTE	[select/start sequence]
PHASE	[<enter> to select output]
SEQ NAME	[<enter> to select sequence]
CONTROL	[start/stop sequence]

3.3.6 INSTR (Instrument) Menu

The **INSTR** menu allows the user to:

- Set the output range for each phase (156 or 312 volts).
- Select either AC or DC coupling.
- Select the peak overvoltage limit.
- Select either shutdown, foldback or time–out mode (foldback for the time specified in the ITIMO field then shutdown mode).
- Select the time for the time–out mode.



INSTR Menu Status and Information Line Data

Item	Status and Information Line Readout
RANGE	[156V or 312V range]
COUPLING	[AC or AC + DC coupling]
VLIM	[peak voltage limit]
I MODE	[supervisory current mode]
I TIMO	[current limit time–out]
#PHASE	[single or 3–phase output]

CAUTION

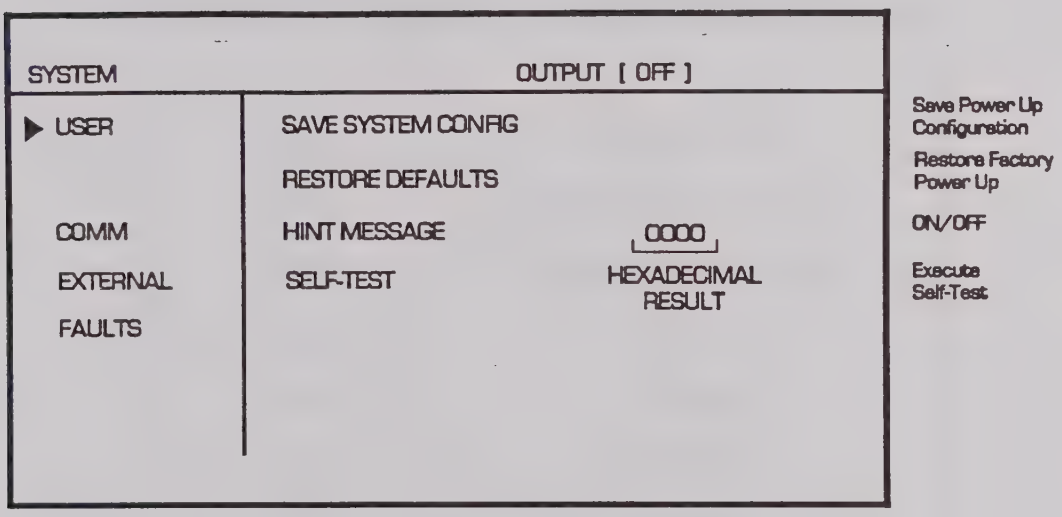
#PHASE must match the rear panel output wiring.

3.3.7 SYSTEM Menu

- Configure power up values.
- Execute the unit's self–test.

3.3.7.1 USER Sub–Menu

The SYSTEM **USER** menu allows the user to:



USER Sub–Menu Status and Information Line Data

Item	Status and Information Line
USER	[power–up config & self–test]
SAVE SYSTEM CONFIG	[store new power–up setting]
SELF–TEST	[execute self–test]
HINT MESSAGE	[hint messages on/off]

SAVE SYSTEM CONFIG will save the current system configuration of the Program and Instrument menus and initialize the SW 5250 to these settings on power up.

RESTORE DEFAULTS will reset the power up configuration to factory defaults.

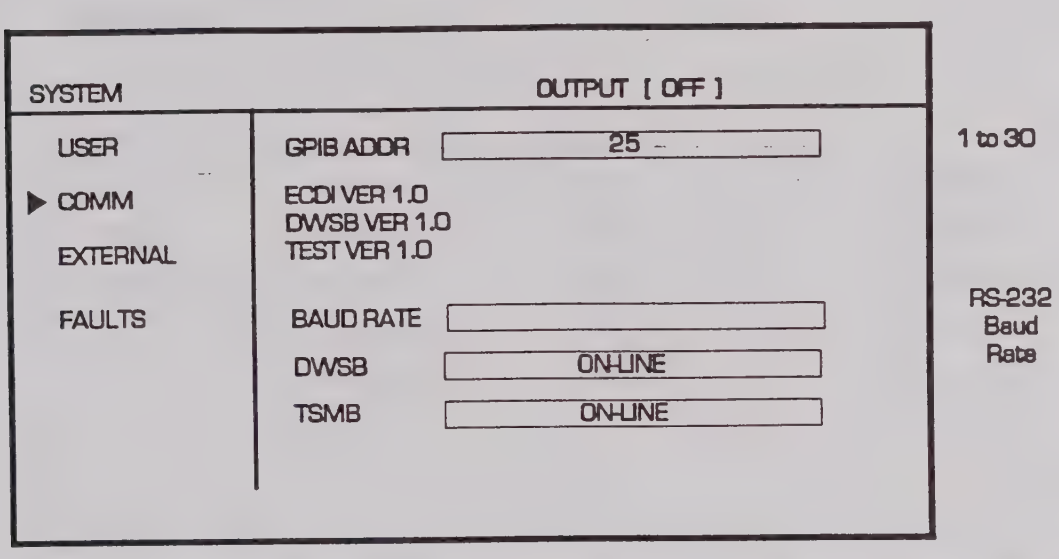
SELF-TEST Results Definitions

Bit	Meaning
0001	LCD Test
0002	EPROM CKSUM
0004	NURAM BANK 0 CKSUM
0008	NURAM BANK 1 CKSUM
0010	RAM Test
0020	VXI Test
0040	QSCI Test
0080	GPIB Test
0100	Battery Test
0200	QSPI Test
0400	DFI Test
0800	Speaker Test
1000	DWSB Self-Test 0
2000	DWSB Self-Test 1
4000	T&MB Self-Test 0
8000	T&MB Self-Test 1

3.3.7.2 COMM Sub-Menu

The SYSTEM **COMM** (Communications) menu allows the user to:

- Configure the GPIB address and display remote status.
- Display firmware version information.



The DWSB and TSMB fields indicate the internal communication status of the Digital Waveform Synthesis board and Test and Measurement board. These should always indicate **ON-LINE** unless a failure has occurred.

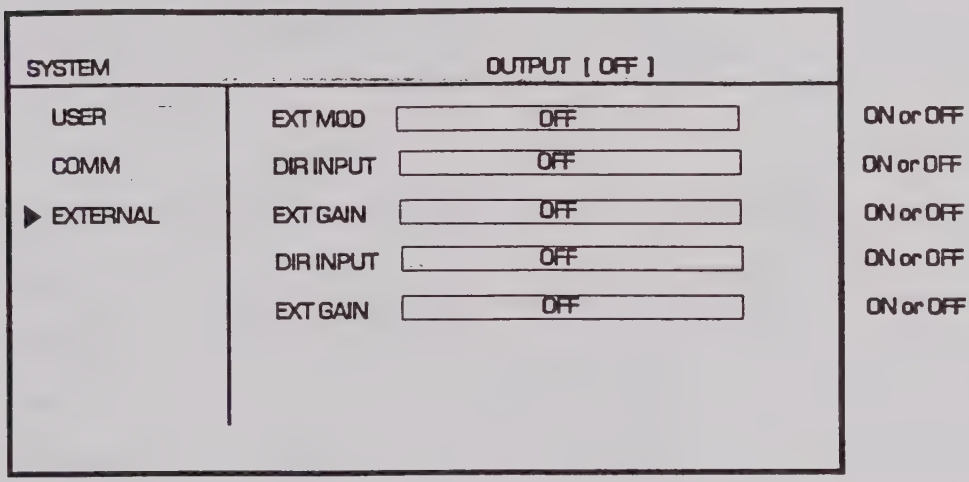
COMM Sub-Menu Status and Information Line Data

Item	Status and Information Line
COMM	[communication configuration]
GPIB ADDR	[select gpib address]
ECDI VER 1.0 DWSB VER 1.0 TEST VER 1.0	[installed firmware version]
BAUD RATE	[RS-232 Baud Rate]

3.3.7.3 EXTERNAL Sub-Menu

The SYSTEM **EXTERNAL** menu allows the user to:

- Select External amplitude modulation.
- Select External direct input to the amplifiers.
- Select External gain control (0V to 5 V TTL).



X-LOAD reduces overshoot, undershoot, and ringing with unusual reactive loads. This option should not be used with normal loads.

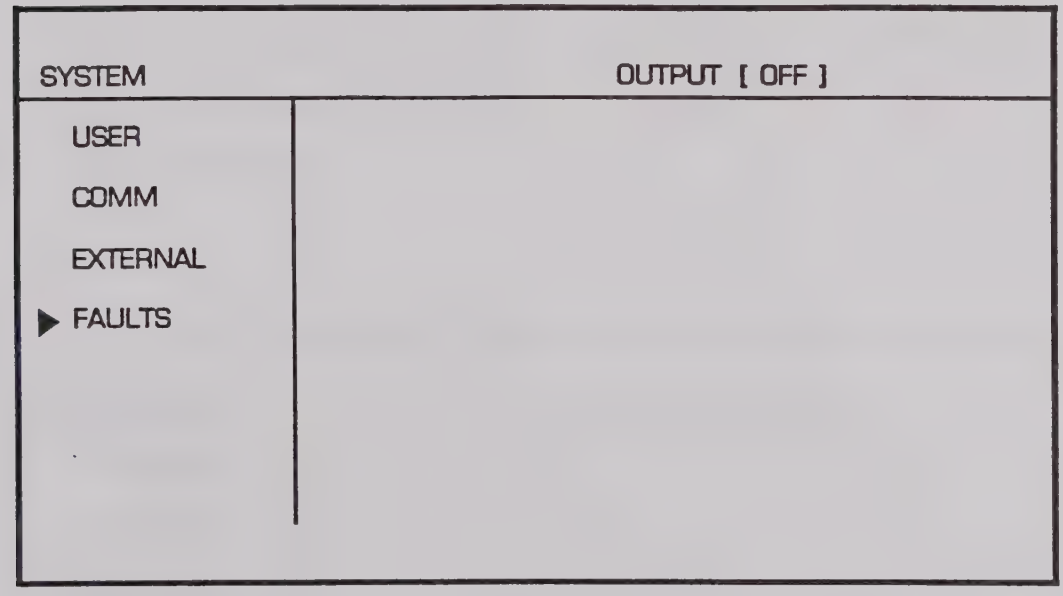
LOW FREQ is used for external AC input signals between DC and 40 Hz. This option should not be used in normal operation, with a DC input, or at frequencies greater than 40 Hz.

EXTERNAL Sub-Menu Status and Information Line Data

Item	Status and Information Line
EXTERNAL	[external input control]
EXT MOD	[external modulation]
DIR INPUT	[external direct input]
EXT GAIN	[external gain control]

3.3.7.4 FAULTS Sub–Menu

Pressing <Enter> to select FAULTS will display a list of logged fault conditions LOG1 – LOG7. These are three 8–bit registers used to troubleshoot errors that cause the system to shut down. Fault register definitions are available through the Help screens of the SW 5250.



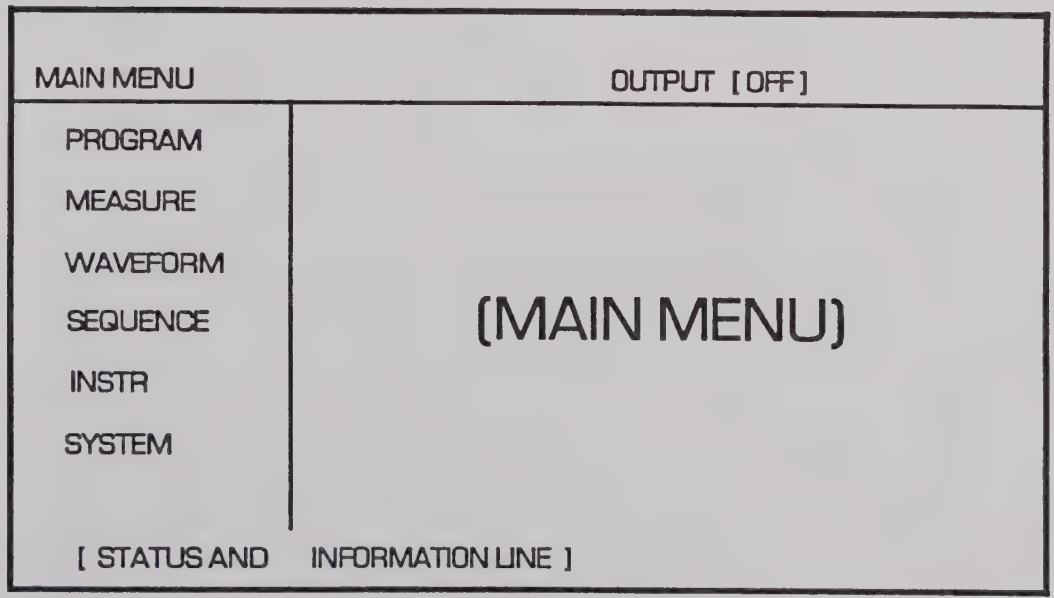
3.4 PROGRAMMING RULES

- Phases A, B, and C will be of the same frequency. A frequency change of any phase will affect the output frequency of all phases. The frequency field is available in all three programming screens as a convenience.
- A sequence can be run on one, two, or all three phases. Two different sequences cannot be run on two phases simultaneously.
- A sequence setting will take priority over continuous settings. When a sequence is terminated, all programming AMPL values are set to 0.

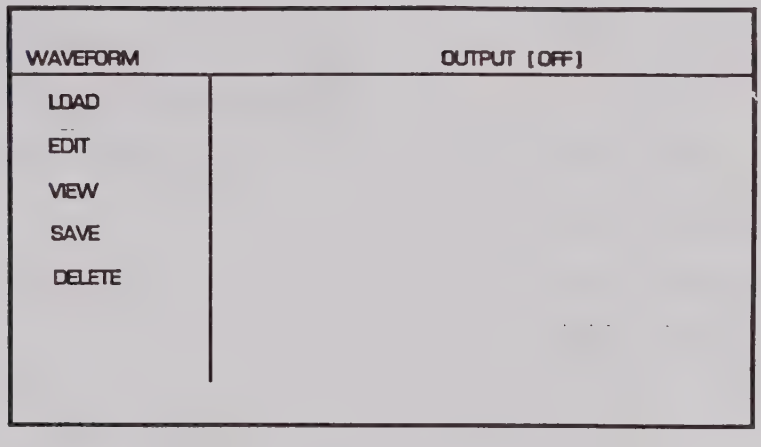
3.5 PROGRAMMING EXERCISES

3.5.1 Current Inrush Example

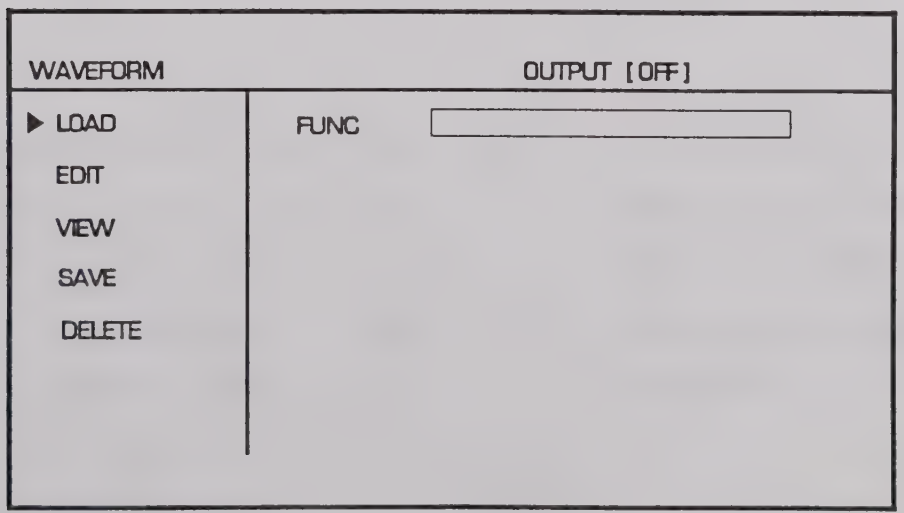
In this example the user programs the SW 5250 to simulate a current inrush waveform that is 0V between 0° and 90°, then instantaneously jumps from 0V to 120V at 90°.



1. At the **MAIN MENU**, using either the Knob or the up/down Arrow Cursor Keys, select the **WAVEFORM** menu then either press the <Enter> key or the right Arrow Cursor Key.



2. The **WAVEFORM** Menu will default to the **LOAD** sub–menu. If **LOAD** is not the default, use the **Knob** or Arrow Cursor Keys to select LOAD.



3. Press the <Enter> key to enter the **FUNC** (function) mode.

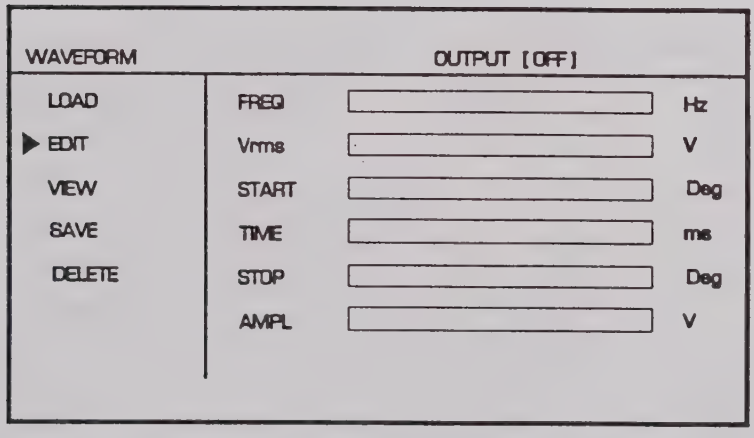
4. Press <Enter> again to place a box around the waveshape selection.

5. If required, using the Knob, rotate through the waveshape selections until **SINE** is observed in the FUNC box.

6. Press <Enter>; this loads the sine waveshape into scratchpad memory. A message, **[waveform successfully loaded]**, will indicate that the waveform is now in scratchpad memory.

7. Press <Menu> to return to the WAVEFORM Menu.

8. Using either the Knob or the up/down Arrow Cursor Keys, select the **EDIT** sub–menu then either press <Enter> or the right Arrow Cursor Key. The EDIT menu will be displayed.



9. Using either the Knob or the up/down Arrow Cursor Keys, select **FREQ**. The frequency is normally defaulted at 60 Hz with all other values set to 0. Using the **Keypad**, enter "6," "0," "decimal point", "0," "0" then press <Enter> to set the frequency to 60.00 Hz.

10. Using either the Knob or the up/down Arrow Cursor Keys, select **Vrms**. Using the Keypad, enter "1," "2," "0" then press <Enter> to set the RMS voltage to 120 volts.

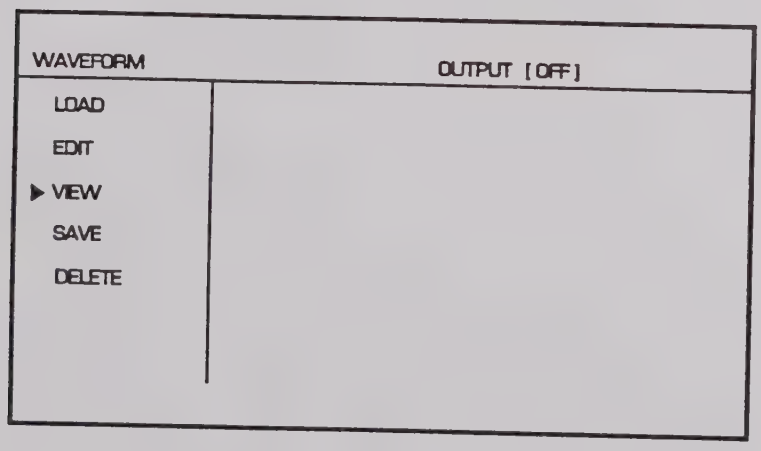
11. Using either the Knob or the up/down Arrow Cursor Keys, select **START**. Using the Keypad, enter "0" then press <Enter> to set the start phase angle to 0°.

12. Although the TIME could be calculated then entered, in this example the **STOP** function will be used. Select **STOP** then enter "90" for a 90° phase angle then press <Enter>. Note that the instrument automatically calculates the **TIME** (in this case, 4.17 ms).

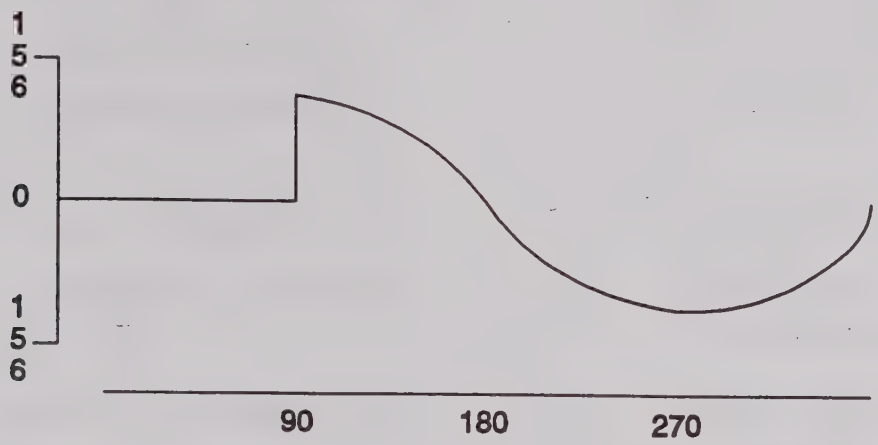
13. Since the operator is not programming a transient (drop/spike), leave the **AMPL** (amplitude) at 0V.

14. Using either the <Menu> key or the left Arrow Cursor Key, press the key to return to the WAVEFORM Menu.

15. Select **VIEW** then press <Enter> to view the waveform on the LCD.



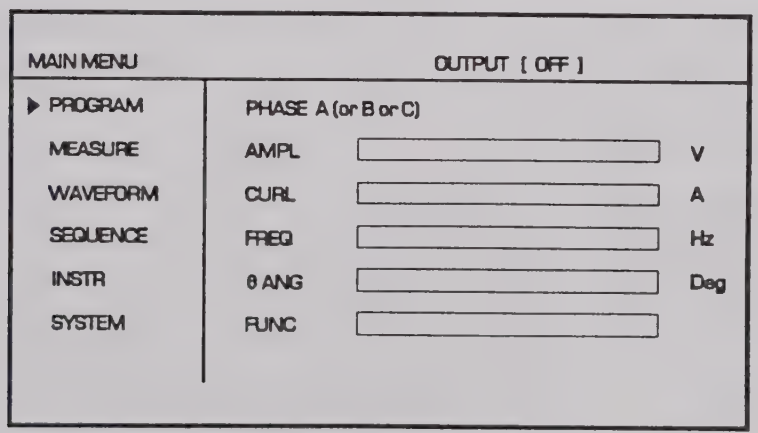
A waveform similar to the one below should be displayed on the LCD.



16. To display the waveform on the oscilloscope:

a. Return to the **MAIN MENU** by pressing <Menu> twice.

b. Select the **PROGRAM** Menu then press <Enter>.



17. In the **PHASE A** sub–menu:

    a. Select **FUNC** with the Knob then press <Enter> to place a box around the waveshape selection.

    b. If required, turn the Knob until **"SCRATCH"** is displayed, then press <Enter>.

18. While still in the **PHASE A** sub–menu:

    a. Select **AMPL** (amplitude) with the Knob or Arrow Cursor Keys.

    b. Enter "120" volts with the Keypad to set the amplitude at **120** volts then press <Enter>. The inrush waveform will now be displayed on Phase A of the oscilloscope.

19. While still in the **PROGRAM** mode:

    a. Select **PHASE B** by cursoring to Phase A, then press <Enter>.

    b. Select **FUNC** with the Knob, then press <Enter> to place a box around the waveshape selection.

    c. Rotate the Knob to select **TRIANGLE**, then press <Enter>.

    d. Select **AMPL** (amplitude) with the Knob, enter "120" volts with the Keypad, then press <Enter>. A triangular waveform will be displayed on Phase B of the oscilloscope.

    e. With the select cursor still at **AMPL**, press <Enter> to place a box around the waveshape selection then, using the Knob, vary the amplitude of the triangular waveform on Phase B.

f. Select **PHASE C** by cursoring to Phase B, then press <Enter>.

g. Select **FUNC** with the Knob, then press <Enter> to place a box around the waveshape selection.

h. Rotate the Knob to select **SQUARE**, then press <Enter>.

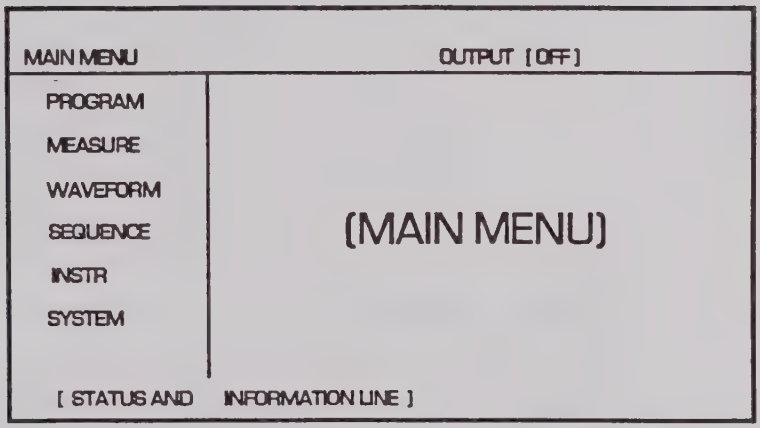
i. Select **AMPL** (amplitude) with the Knob, enter "120" volts with the Keypad, then press <Enter>. A square waveform will now be displayed on Phase C of the oscilloscope.

j. With the select cursor still at **AMPL**, press <Enter> to place a box around the waveshape selection then, using the Knob, vary the amplitude of the square waveform on Phase C.

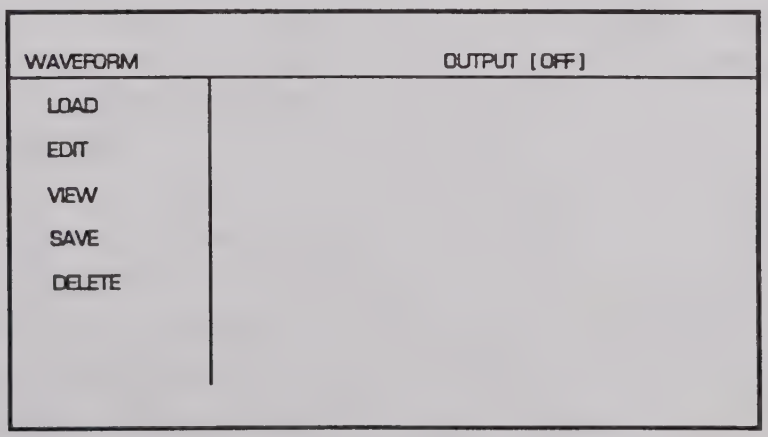
20. Using either the <Menu> key or the left Arrow Cursor Key, return to the MAIN MENU.

3.5.2 Voltage Spike Example

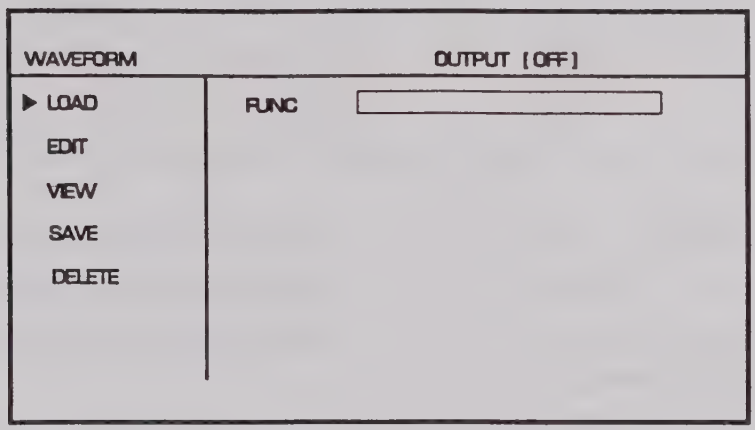
In this example the user programs the SW 5250 for a voltage spike on a 120V sine waveform that starts at 30°, ends at 32°, and is of maximum amplitude (in this case, 156V).



1. At the **MAIN MENU**, select the **WAVEFORM** menu, then press <Enter>.



2. The **WAVEFORM** Menu should default to the **LOAD** sub–menu. If **LOAD** is not the default, use the Knob or Arrow Cursor Keys to select LOAD.



3. Press <Enter> to enter the **FUNC** (function) mode.

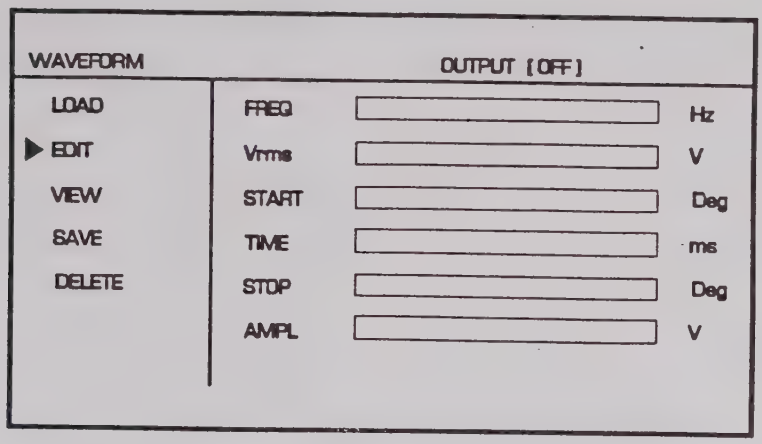
4. Press <Enter> again to place a box around the waveshape selection.

5. If required, using the Knob, rotate through the waveshape selections until **SINE** is observed in the FUNC box.

6. Press <Enter>; this loads the sine waveshape into scratchpad memory. A message, **[waveform successfully loaded]**, will indicate that the waveform is now in scratchpad memory.

7. Press <Menu> to return to the WAVEFORM Menu.

8. Using either the Knob or the up/down Arrow Cursor Keys, select the **EDIT** sub–menu then either press <Enter> or the right Arrow Cursor Key. The EDIT menu will be displayed.



9. Select **Vrms**. Enter "120" using the Keypad then press <Enter> to set the RMS voltage to 120 volts.

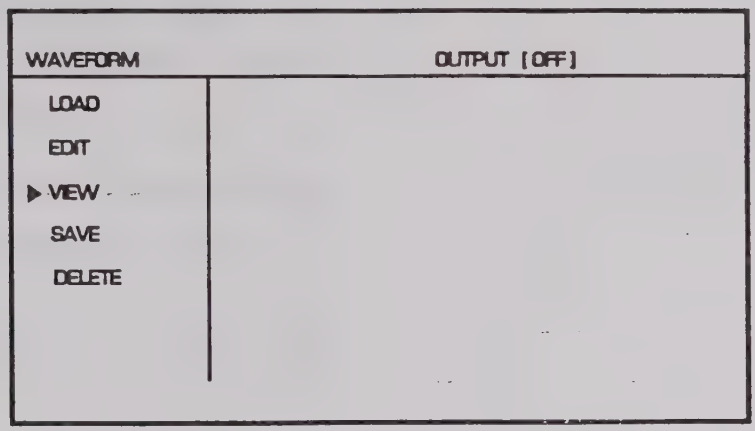
10. Select **START**. Enter "30" using the Keypad then press <Enter> to set the starting phase angle to 30°.

11. Select **STOP**, enter "32" using the Keypad for an ending phase angle of 32°, then press <Enter>. Note that the instrument automatically calculates the **TIME** (in this case, 0.09 ms).

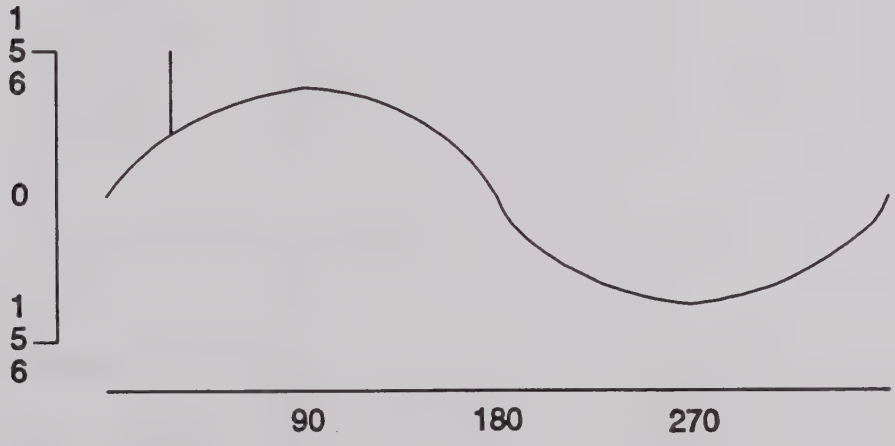
12. Select **AMPL** then press <Enter>. Enter "156" (the maximum output amplitude at the selected range), then press <Enter> again.

13. Return to the WAVEFORM Menu by pressing <Menu>.

14. Select **VIEW** to view the scratchpad.



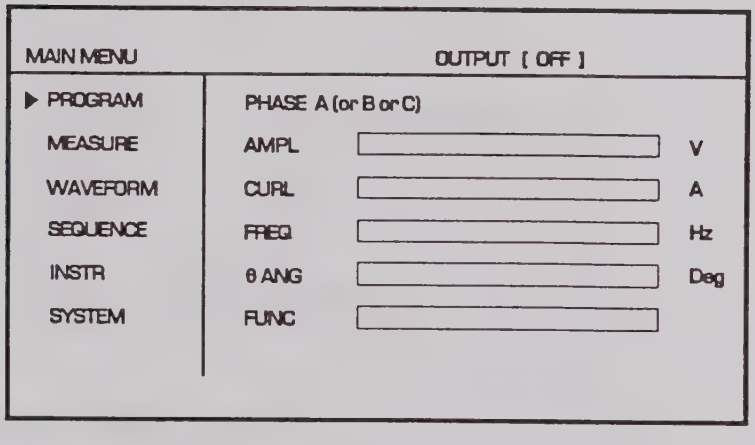
15. Press <Enter>. A waveshape similar to the one below should be displayed on the scratchpad.



16. To retain the waveshape and display it on Phase A of the oscilloscope:

    a. Return to the **MAIN MENU** (press <Menu> twice).

    b. Select the **PROGRAM** Menu then press <Enter>.



17. In the **PHASE A** sub–menu:

    a. Select **FUNC** with the Knob then press <Enter> to place a box around the waveshape selection.

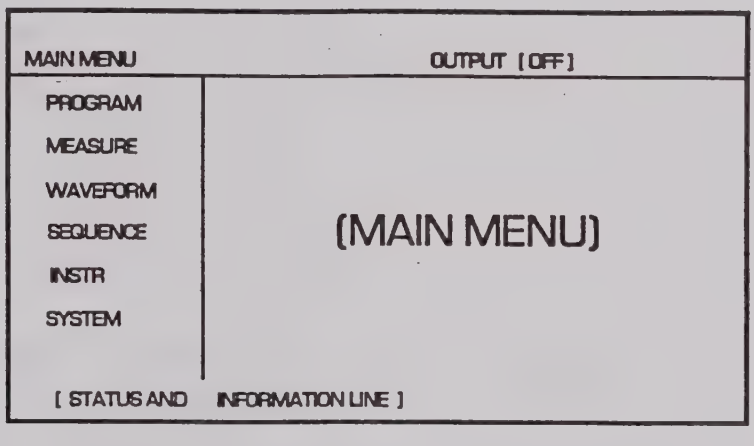
    b. If required, turn the Knob until **SCRATCH** is displayed, then press <Enter>.

    c. The scratchpad waveform will now be displayed on Phase A of the oscilloscope.

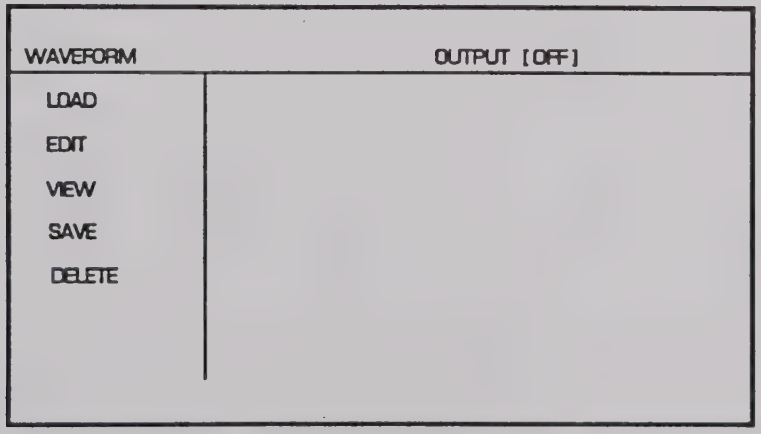
18. Using <Menu>, return to the MAIN MENU.

3.5.3 Voltage Dropout Example

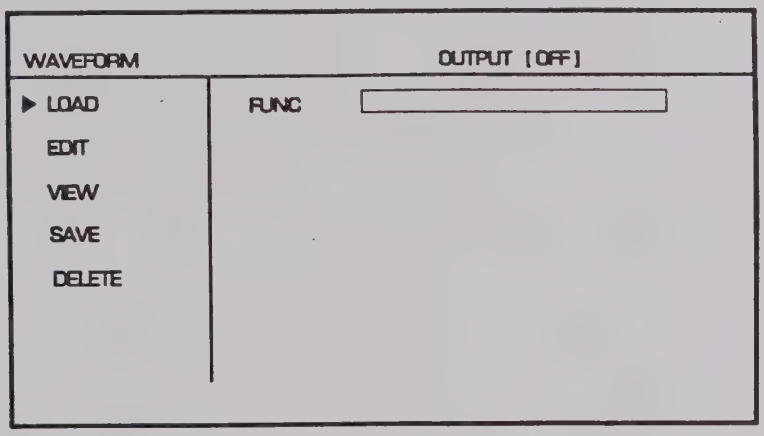
In this example the user programs the SW 5250 for a voltage dropout on a 120V sine waveform that starts at 45° with a duration of 1 millisecond and an amplitude of 10 volts.



1. At the **MAIN MENU**, select the **WAVEFORM** menu, then press <Enter>.



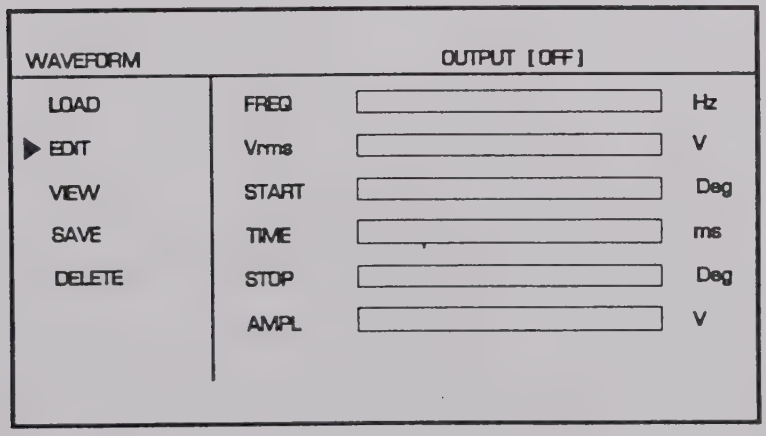
2. At the **WAVEFORM** Menu, select the **LOAD** sub–menu then press <Enter>. The LOAD menu will be displayed.



3. Press <Enter> to place a box around the waveform selection, select **SINE**, then press <Enter>. The sine waveshape is loaded into scratchpad memory.

4. Return to the **WAVEFORM** Menu by pressing <Menu>.

5. Select the **EDIT** sub–menu then press <Enter>. The EDIT menu will be displayed.



6. Select **Vrms**. Enter "120" then press <Enter> to set the RMS voltage to **120** volts.

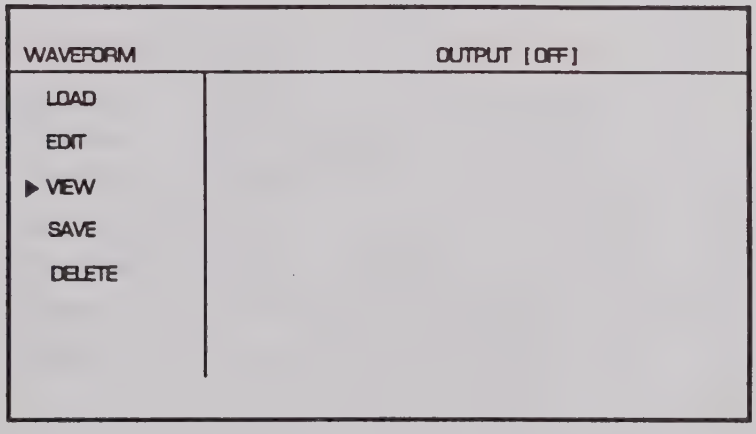
7. Select **START**. Using the Keypad, enter "45" then press <Enter> to set the starting phase angle to **45°**.

8. Select **TIME**, enter "1" for a duration of 1 millisecond, then press <Enter>. Note that the instrument automatically calculates the **STOP** phase angle value (in this case, 66.6°).

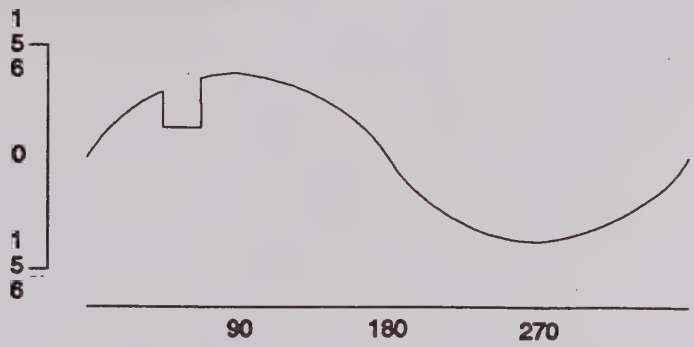
9. Select **AMPL**, enter "10" for 10 volts, then press <Enter>.

10. Return to the WAVEFORM Menu by pressing <Menu>.

11. Select **VIEW** to view the scratchpad.



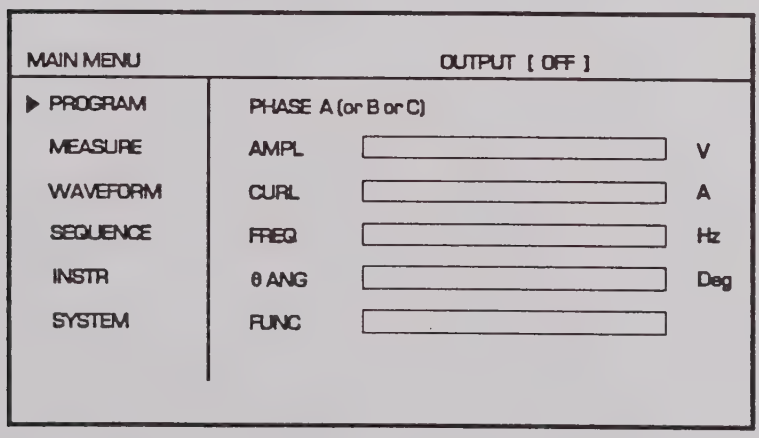
12. Press <Enter>. A waveshape similar to the one below should be displayed on the scratchpad.



13. To retain the waveshape and display it on Phase A of the oscilloscope:

a. Return to the **MAIN MENU** (press <Menu> twice).

b. Select the **PROGRAM** Menu, then press <Enter>.



14. In the **PHASE A** sub-menu, select **FUNC**, select **SCRATCH**, then press <Enter>. The scratchpad waveform will now be displayed on Phase A of the oscilloscope.

15. Using either the <Menu> key or the left Arrow Cursor key, return to the MAIN MENU.

3.6 SCPI SPECIFICATION

See the SmartWave™ SW Series SCPI Specification Manual (M162000–03).

NOTES

ELGAR

SmartWave™

SW Series

SCPI Specification

ELGAR CORPORATION
9250 Brown Deer Road
San Diego, CA 92121

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Document No. M162000-03 Rev. 01

September 23, 1994

Elgar One Year Warranty

EL SERIES, LINE CONDITIONERS, UPS, GUPS, GPS, DC, VXP, AND SW

Elgar Corporation (hereinafter referred to as Elgar) warrants its products to be free from defects in material and workmanship. This product warranty is effective for one year from the date of shipment to the original purchaser. Liability of Elgar under this warranty shall exist provided that:

- the Buyer exposes the product to normal use and service and provides normal maintenance on the product;
- Elgar is promptly notified of defects by the Buyer and that notification occurs within the warranty period;
- the Buyer receives a Return Material Authorization (RMA) number from Elgar's Customer Service Department prior to the return of the product to Elgar for repair, phone 800-73-ELGAR (800-733-5427), ext. 295;
- the Buyer returns the defective product in the original, or equivalent, shipping container;
- if, upon examination of such product by Elgar it is disclosed that, in fact, a defect in materials and/or workmanship does exist, that the defect in the product was not caused by improper conditions, misuse, or negligence; and,
- that Elgar markings and nameplates have not been altered or removed and the equipment has not been repaired or modified by anyone other than Elgar authorized personnel.

This warranty is exclusive and in lieu of all other warranties, expressed or implied, including, but not limited to, implied warranties of merchantability and fitness of the product to a particular purpose. Elgar, its agents, or representatives, shall in no circumstance be liable for any direct, indirect, special, penal, or consequential loss or damage of any nature resulting from the malfunction of the product. Remedies under this warranty are expressly limited to repair or replacement of the product.

CONDITIONS OF WARRANTY

- To return a defective product, contact an Elgar representative or the Elgar factory for an RMA number. Unauthorized returns will not be accepted and will be returned at the shipper's expense.
- For Elgar products found to be defective within thirty days of receipt by the original purchaser, Elgar will absorb all ground freight charges for the repair. Products found defective within the warranty period, but beyond the initial thirty-day period, should be returned prepaid to Elgar for repair.
- Normal warranty service is performed by Elgar during the weekday hours of 7:30 am to 4:30 pm Pacific time. Warranty repair work requested to be accomplished outside of normal working hours will be subject to Elgar non-warranty service rates.
- Warranty field service is available on an emergency basis. Travel expenses (travel time, per diem expense, and related air fare) are the responsibility of the Buyer. A Buyer purchase order is required by Elgar prior to scheduling.
- A product found, upon inspection by Elgar, to be in specification is subject to an inspection fee and applicable freight charges.
- Equipment purchased in the United States carries only a United States warranty for which repair must be accomplished at the Elgar factory.

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SAFETY NOTICE

BEFORE APPLYING POWER to the System, verify that the SW Series unit is properly configured for the user's particular application.

WARNING

HAZARDOUS VOLTAGES IN EXCESS OF 280 VRMS, 600V PEAK MAY BE PRESENT WHEN COVERS ARE REMOVED. QUALIFIED PERSONNEL MUST USE EXTREME CAUTION WHEN SERVICING THIS EQUIPMENT. CIRCUIT BOARDS, TEST POINTS AND OUTPUT VOLTAGES MAY ALSO BE FLOATING ABOVE (BELOW) CHASSIS GROUND.

Installation and servicing must be performed by QUALIFIED PERSONNEL who are aware of properly dealing with attendant hazards. This includes such simple tasks as fuse verification.

Ensure that the AC power line ground is properly connected to the SW Series unit input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment MUST be properly grounded for both personnel and equipment safety.

Always ensure that facility AC input power is de-energized prior to connecting or disconnecting the input/output power cables.

In normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, **HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY** may be normally generated on the output terminals. The Customer/User must ensure that the output power lines are properly labeled as to the SAFETY hazards and any that inadvertent contact with hazardous voltages is eliminated.

Guard against risks of electrical shock during open cover checks by NOT TOUCHING any portion of the electrical circuits. Even when power is OFF, capacitors may retain an electrical charge. Use SAFETY GLASSES during open cover checks to avoid personal injury by any sudden component failure.

Due to filtering, the unit has high leakage current to the chassis. For this reason it is essential to operate this unit with a safety ground.

Some circuits are live even with the front panel switch turned off. Servicing, and even fuse verification and connecting wiring to the chassis, must be accomplished with the power removed via external means; all circuits and/or terminals to be touched must be safety grounded to the chassis. This should be accomplished after waiting at least five minutes after the last power application to the unit.

After the unit has run for some time the metal near the rear of the unit may be hot enough to cause injury. Let the unit cool before handling.

Qualified service personnel need to be aware that some heatsinks are not at ground, but are at high potential.

European versions use 380V 3–phase power. These systems **must have neutral connections; the neutral must not be switched**. Neutral needs to be applied before phase voltage is applied or serious damage to the equipment may result.

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SECTION I

GENERAL

1.1 SCPI CONFORMANCE INFORMATION

The Elgar SW Series conforms to all specifications for devices as defined in IEEE 488.2, and complies with SCPI command syntax version 1993.0. Conformed Commands are those commands which are approved commands in the SCPI 1993 Specification, Volume 2: Command Reference. They are denoted by a (C) in the following command reference. Any commands that are not Confirmed Commands have been submitted to the SCPI Consortium and are labeled as Not Approved (N).

1.2 SCPI COMMAND FORMAT

The SCPI commands perform functions such as closing switches, making measurements, and querying instrument states or receiving data. A subsystem command structure is a hierarchial structure that usually consists of a top level (or root) command, one or more lower level commands, and their parameters. The following example shows part of a typical subsystem:

```
SOUR1:
    :CURR <value>
    :FREQ <value>
        :MODE?
```

Where SOUR1: is the root command, CURR and FREQ are second level commands with parameters, and MODE? is a third level command.

1.2.1 Command Separator

Colons separate the root command from the second level command (SOUR1:FREQ) and the second level command from the third level (FREQ:MODE?).

1.2.2 Abbreviated Commands

The command syntax shows most commands as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, send the entire command. The unit will accept either the abbreviated form or the entire command.

For example, if the command syntax shows SOURce, then SOUR and SOURCE are both acceptable forms. Other forms of the command may generate an error. Upper or lower case letters may be used; therefore, SOURCE, source, and SouRce are all acceptable.

1.2.3 Conventions Commands

Optional implied commands are those that appear in square brackets ([ ]) in the command syntax (the brackets are **not** part of the command, are not sent to the instrument). For example, a fourth level command is sent without the preceding implied command. In this case, the unit assumes that the user intended to use the implied command and responds as if it has been sent:

```
SOUR1
:CURR
    :[LEV]
        :[IMM]
```

The root command is SOUR. The implied command ;[LEV] at the third level is not necessary. For example, to set the unit's current, send either of the following command statements:

```
SOUR1:CURR:LEV:IMM 1234
        or
SOUR1:CURR 1234
```

1.2.4 Parameter Types

Table 1–1 contains explanations and examples of parameter types used in this section.

Table 1–1. Parameter Types

Parameter Type	Explanation
<boolean>	"ON," "OFF," 0 or 1
<value>	Integer or Floating Point number
<name>	String enclosed by single or double quotes

1.2.5 Units

The SW Series will accept the units as suffixes to numeric values as indicated in Table 1–2.

Table 1–2. Units

Type of Unit	Valid Suffix
Voltage	"Volts" or "V"
Current	"Amps" or "A"
Frequency	"Hz"
Time	"ms" (milliseconds", "s" (seconds) or "min" (minutes)

1.2.6 Queries

The query syntax is identical to the command syntax, with a "?" appended. For example, to query the programmed voltage on phase A, send the string: **SOURce:VOLTage?** A subsequent device read will return a value such as "120.00V." All queries are terminated with a carriage return and line feed (0x0D 0x0A) for those GPIB controllers that require termination characters. When the SW Series has nothing to report, its output buffer will contain three ASCII characters: a space, a carriage return, and a line feed (in decimal, the values are <32><13><10>).

1.3 COMMON COMMANDS

Table 1–3 contains the commands that are common to all SCPI instruments and declared mandatory by IEEE 488.2. In the table, the SW Series will be defined as the "device" on the GPIB bus.

Table 1–3. Common Commands

Command	IEEE 488.2 Definition	
*CLS	Clear Status Command. Clears all status reporting data structures, including the Status Byte, Standard Event Status Register and Error Queue. Enable masks are not cleared.	C
*ESE	Standard Event Status Enable Command. Sets the Standard Event Status Enable Register, which determines which bits can be set in the Standard Event Status Register.	C
*ESE?	Standard Event Status Enable Query. Returns the value of the Standard Event Status Enable register.	C
*ESR?	Standard Event Status Register Query. Returns the value of the Standard Event Status Register. The ESR and the Status Byte ESR bit are cleared.	C
*IDN?	Identification Query. Returns the device identity as an ASCII string: <manufacturer>, <model>, <serial number>, <firmware level>. Example: Elgar, Sw Series 5250, 1234, 1.0	C
*OPC	Operation Complete Command. Causes the Operation Complete bit to be set in the Standard Events Status Register when all pending operations are complete.	C

Command	IEEE 488.2 Definition	
*OPC?	Operation Complete Query. Causes an ASCII "1" to be placed in the output queue when all pending operations are complete.	C
*RST	Reset Command. Resets the device to the state defined in paragraph 1.4. Clears all status reporting data structures, including the Status Byte, Standard Event Status Register and Error Queue. Enable masks are not cleared.	C
*SRE	Service Request Enable Command. Sets the Service Request Enable Register, which determines which bits in the Status byte will cause a service request from the device.	C
*SRE?	Service Request Enable Query. Returns the contents of the Service Request Enable register. Values range from 0 to 63 or 128 to 191.	C
*STB?	Read Status Byte Query. Returns the Status Byte with bit 6 representing the Master Summary Status (MS) instead of RQS. The MSS bit acts as a summary bit for the Status Byte, and indicates whether or not the device has at least one reason to request service, based on the MAV and SESR bits. The return value is in the range of 0 – 255. The Status Byte is cleared after the read.	C
TST?	Self–Test Query. Causes the device to execute an internal self–test and report whether or not it detected any errors. A value of "0" indicates the test completed without detecting any errors.	C
*WAI	Wait–to–Continue Command. Makes the device wait until all previous commands and queries are complete before executing commands following the *WAI command.	C

1.4 STATUS REGISTER DEFINITIONS

See Appendix A.

1.5 STANDARD SEQUENCES

See Appendix C.

1.6 ERROR CODES

See Appendix D.

1.7 POWER ON CONDITIONS

The following paragraphs define the factory and reset power on conditions of the unit. Note that if the power on self-test fails, no GPIB commands will be serviced until the fault window on the front panel LCD is cleared by the keypad <Enter> key.

1.7.1 Factory Defaults

When the unit is first powered up, the factory defaults listed in Table 1–4 will be in place:

Table 1–4. Factory Defaults

GPIB Address	25
RS–232 Baud Rate	57600
Number of phases (Amplifiers) in Chassis	3

1.7.2 Reset Condition

At power up, or when the *RST command is sent, the SW Series will be reset to the following states:

- **Amplifier Outputs**

Voltage: 0.0

Current Limit: 5.0

Frequency: 60.0

Phase Angle: 0, 120, 240

Function: Sine

- **Measurement Subsystem**

All measurements are cleared.

- **Waveform Subsystem**

The waveform scratchpad is cleared.

- **Sequence Subsystem**

The sequence scratchpad is cleared.

The Sequence Execute RUN/STOP field is set to STOP. Any sequences running when a *RST command is received are terminated.

User Sync is set to "Every Segment."

- **Instrument Subsystem**

Range is set to 156 volts.

Coupling is set to AC.

Sync is set to Cycle Start.

Current mode is set to SHUTDOWN.

Current Timeout value is set to 100 ms.

Overvoltage limit is set to 195.0 Vpeak (120 VRMS + 10%).

- **System Subsystem**

Self–test status will be reset.

- **Mass Memory Subsystem**

The default upload/download format is ASCII.

NOTES

SECTION II

SUBSYSTEMS

2.1 INTRODUCTION

The programming subsystems consist of the following:

- Calibration
- Display
- Edit
- Measure
- Mass Memory
- Output
- Source
- System

2.2 CALIBRATION SUBSYSTEM

2.2.1 Description

There are two categories of calibration on the SW: Output and Measurement. The CALibration:OUTPut commands calibrate the programmable output voltage and current limit. The CALibration:MEASure commands calibrate the internal test and measurement board.

Calibration of the SW requires an external voltmeter, a current shunt, and a programmable load connected to its output.

There are a total of 46 calibration factors in a three–phase system with a Test and Measurement board installed (16 for output calibration and 30 for test and measurement). Each number is based on the system configuration (three–phase or single–phase output) and the range (156V/312V). See Table 2–1.

Table 2–1. Calibration Subsystem

Parameter	Output Configuration	Output/Input Channel	Range
Output Voltage	Three–phase	Phase A	Low
		Phase B	Low
		Phase C	Low
		Phase A	High
		Phase B	High
		Phase C	High
	Single–phase	Phase A	Low
		Phase A	High
Output Current	Three–phase	Phase A	Low
		Phase B	Low
		Phase C	Low

Parameter	Output Configuration	Output/Input Channel	Range
		Phase A	High
		Phase B	High
		Phase C	High
	Single–phase	Phase A	Low
		Phase A	High
Measured Voltage	Three–phase	Phase A	N/A
		Phase B	N/A
		Phase C	N/A
Measured RMS Current	Three–phase	Phase A	Low
		Phase B	Low
		Phase C	Low
		Phase A	High
		Phase B	High
		Phase C	High
	Single–phase	Phase A	Low
		Phase A	High
Measured Peak Current	Three–phase	Phase A	Low
		Phase B	Low
		Phase C	Low
		Phase A	High
		Phase B	High
		Phase C	High
	Single–phase	Phase A	Low
		Phase A	High
Measured Power	Three–phase	Phase A	Low
		Phase B	Low
		Phase C	Low
		Phase A	High
		Phase B	High
		Phase C	High
	Single–phase	Phase A	Low
		Phase A	High
Measured Phase Angle	Three–phase	Phase A	N/A
		Phase B	N/A
		Phase C	N/A

2.2.2 Terminology

There are separate calibration factors for the different operating modes of the SW. For example, the output voltage has calibration factors for both three–phase and single–phase operation, and for low range and high range in each mode; a total of four calibration factors for a single amplifier.

Every calibration function requires a sample number and the sample value. The calibration factor affected will depend on the programmed range (low or high) and mode (single–/three–phase) settings.

The calibration subsystem commands use the following notation:

Variable	Description
<#>	Sample number. • Each OUTPut calibration factor is based on 1 or the average of 2 measurements. The sample number range is from 1 to 2. • Each MEASure calibration factor is based on the average of 2 measurements. • A sample number of 0 will instruct the SW to average the entered measurement data.
<value>	Represents the measurement value from an external meter. Each value must be preceded by a sample number.

2.2.3 Procedure

To calibrate the output voltage in three–phase mode and low range at two points, perform the following:

1. Configure the SW to three–phase mode, low range.
2. Connect a voltmeter to the output of phase A.
3. Send **CALibration:OUTPut:CLEAR** to reset the current and voltage calibration factors (for three–phase and low range).
4. Program the output to approximately 20% of full scale.
5. Read the voltage from the voltmeter (this is the <value>).

6. Send **CALibration1:OUTPut: VOLTage 2 <value>.**

7. Program the output to approximately 80% of full scale.

8. Send **CALibration1:OUTPut VOLTage 2 <value>.**

9. Send **CALibration1:OUTPut VOLTage 0 0** to calculate the calibration factor based on the two samples.

Note

The CLEAR command must be sent before programming the output voltage in any calibration procedure (see above example).

2.2.4 Commands

See Table 2–2.

Table 2–2. Calibration Subsystem Commands

CALibration[n]	System Calibration subsystem. n = 1, 2 or 3 indicating the output phase to be calibrated.	C
:DATA <block>	Cal data input. "block" is used to transfer the entire cal structure. Use DATA subcommands to calibrate specific functions.	N
:MEASure	Calibrate the internal test and measurement board. A query command will return a gain and offset.	N
:CLEAR	Clears the calibration parameters and restores factory defaults for the specified phase[n]. The CLEAR command must be sent to reset the calibration factor before each calibration procedure.	C
:CURRent <#> <value>	Calibrate RMS current measurement. The "#" parameter is the measurement number, and the value is the measurement value from an external meter.	N
:PEAK <#> <value>	Calibrate peak current measurements.	N
:POWer <#> <value>	Calibrate power measurements.	N
:VOLTage <#> <value>	Calibrate the output voltage measurement. There are three voltage input channels.	N

:OUTPut	Calibrate programmable outputs. A query command will return the gain.	
:CLEAR	Clears the calibration parameters and restores the factory defaults for the specified phase[n]. The CLEAR command must be sent to reset the calibration factor before each calibration procedure.	C
:CURRent <#> <value>	Set the programmable output current scale factor. The "#" parameter is the measurement number, and the value is the measurement value. The calibration factor affected is dependent on the programmed range (low/high) and mode (single–/three–phase).	N
:VOLTage <#> <value>	Sets the programmable output voltage scale factor. The "#" parameter is the measurement number, and the value is the measurement value. The calibration factor affected is dependent on the programmed range (low/high) and mode (single–/three–phase).	N

2.3 DISPLAY SUBSYSTEM

See Table 2–3.

Table 2–3. Display Subsystem

DISPlay		C
:CONTrast <value>	Value ranges from 0 to 1, 1 being full intensity.	C

2.4 EDIT SUBSYSTEM

This subsystem is used to edit waveforms or sequences in scratchpad memory. To load, save or delete waveforms or sequences, use the mass memory subsystem. See Table 2–4.

Table 2–4. Edit Subsystem

EDIT		N
:WAVEform	Waveform record creation/modification subsystem.	N
:AMPLitude <value>	Transient voltage amplitude. This is the modified amplitude between the start and stop phase angles defined below.	N
:FREQuency (value>	Set waveform frequency 40 Hz – 5 kHz. This value is only used in creating the waveform; the waveform may be played back at any frequency.	N
:PHASe	Sets the limits of the transient amplitude.	N
:STARt <value>	Starting transient phase angle.	N
:STOP <value>	Stop transient phase angle.	N
:DURation <value>	The time duration of the transient starting from the PHASe : STARt offset. The default units are seconds.	N
:VRMS <value>	The RMS voltage value of the waveform.	N
:SEQuence	The sequence creation/modification subsystem.	N
:CLEAR	Deletes all segments in the scratchpad.	
:COPY		N
[:SEGment] <src # dst #>	Copies the segment number specified by "src" to the segment number specified by "dst." Both "srt" and "dst" must already exist.	N

:CYCles <value>	The number of segment cycles. Writing this value will modify the DURation value. A comma is required to separate numeric fields.	N
:DELete		N
[:SEGment] <seg_no>	Deletes a single segment in the scratchpad.	N
:DURation <value>	The segment duration. Writing this value will modify the CYCles value. Default units are seconds.	N
:FREQuency <value>	Segment frequency. Writing this value will modify the CYCles value.	N
:RAMP <boolean>	Frequency ramp select.	N
:INSert <seg_no>	Inserts a segment at the segment number specified and sets the segment number 1 greater than the preceding segment.	N
:SOURce[n]	Select the phase output to modify. Valid values for n are 1, 2 or 3. If no n is specified, n = 1 is assumed.	N
:AMPLitude <value>	Output amplitude.	N
:RAMP <boolean>	Amplitude ramp select.	N
:FUNCtion <name>	Output function.	N
:PHASe <value>	Output phase angle.	N
:SEGment <value>	Select segment to modify.	N

2.5 MEASURE SUBSYSTEM

The Measure subsystem utilizes the SW Series Test and Measurement Board. The values are returned in floating point format with a unit suffix of V, A, Hz or DEG. See Table 2–5.

Table 2–5. Measure Subsystem

MEASure[n]	n = 0, 1, 2, or 3 for all phases, Phase A, B or C.	C
:CLEar	Deletes all measurements.	C
:CURRent?	Returns the RMS output current in amps.	C
:PEAK?	Returns the peak output current in amps.	C
:FREQuency?	Returns the output frequency in Hertz.	C
:PHAse?	Returns the output phase angle relative to phase A in degrees. Note that all phase offsets are in terms of phase lag with respect to the reference signal and phase A.	C
:REFerence?	Returns output phase angle relative to the clock/lock reference.	C
:POWer?	Returns the output power in watts.	C
:TOTal?	Returns the total power. The phase [n] has no effect.	C
:POWERFACtor?	Returns the power factor.	C
:TOTal?	Returns the total power factor. The phase [n] has no effect.	C
:VA?	Returns the VA.	C
:TOTal?	Returns the total VA. The phase [n] has no effect.	C
:VOLTage?	Returns the output voltage. AC RMS for sinusoidal waveforms, DC for DC waveforms.	C
:VAB?	Returns the line to line voltage for phases and B and C. The phase [n] has no effect.	N

:VBC?	Returns the line to line voltage for phases and A and B. The phase [n] has no effect.	N
:VCA?	Returns the line to line voltage for phases and C and A. The phase [n] has no effect.	N

2.6 MASS MEMORY SUBSYSTEM

The Mass Memory subsystem is used to create/modify waveforms stored in the SW Series. To conform to SCPI syntax, there are many "types" of memory storage. Each entry of a particular type of memory is called a TABLe. Memory types are shown in Table 2–6.

Table 2–6. Memory Types

Type	Description
Waveform	Waveform storage including standard factory waveforms stored in ROM as well as user–defined waveforms stored in non–volatile RAM.
Sequence	Sequence storage including standard factory sequences stored in ROM as well as user–defined sequences stored in non–volatile RAM.
Setup	User defines front panel setups stored in non–volatile RAM.

Mass Memory subsystem SCPI commands relating to total amount of memory, memory available, storing or deleting tables and entries refer to non–volatile RAM. Only the LOAD command can access table entries stored in ROM. See Table 2–7.

Table 2–7. Mass Memory Subsystem

MMEMory		C
:CATalog	Queries information on the current contents and state of the mass memory. The returned data will have the following format: <value 1>, <value2> {,<string>} value 1 = memory used, in bytes value 2 = memory available, in bytes <string> has the following format: <name>, <type>, <size> Name = name of item type = waveform, sequence or setup size = size in bytes. All information is returned in ASCII.	C
:SEQuence	Catalog sequences.	N
:WAVEform	Catalog waveforms.	N
:DELete	Deletes a file from the specified mass storage area.	C
::SEQuence <name>	Delete sequence.	N
:WAVEform <name>	Delete waveform.	N
:DOWNload	Commands the SW Series to download selected information to the host computer.	C
:SEQuence <name>	Download sequence.	N
:WAVEform <name>	Download waveform. All waveform downloads originate from the Waveform Scratchpad. Library waveforms should be placed in the scratchpad with the MMEM:LOAD:WAVEform command. A waveform consists of 4096 12–bit data points. In ASCII format, 16386 bytes are transferred; in binary format, 8192 bytes are transferred. Example programs are contained in Appendix E.	N

:FORMat <value>	Sets the upload/download format. A value of 0 = ASCII; 1 = Binary. The default is ASCII. Note that in the Binary mode: • The MSB (most significant byte) needs to be sent first (before the LSB) for uploads. • The MSB is the first byte returned from the SW on downloads. • The System GPIB Controller must be configured for an EOI (end or identify) terminator and no EOS (end of string) terminator.	C
:INITialize	Initializes an area of memory, **restoring all factory**–defined waveforms, and **deleting all user**–defined waveforms.	C
:ALL	Initialize waveform, sequence and setup memory.	
:SEQuence	Initialize sequence memory.	N
:WAVEform	Initialize waveform memory.	N
:LOAD	Loads a file from non–volatile memory.	C
:SEQuence <seq_name>	Loads a sequence from non–volatile memory to the sequence scratchpad.	N
:WAVEform <name><value>	Loads a waveform from non–volatile memory to the waveform scratchpad.	N
:SCALef	Set/query scale factor information.	N
:WAVEform <name><value>	Sets the user–defined waveform record scale factor. Note that this command will only work on user–defined waveforms stored in non–volatile memory.	N
:STORE	Stores a file to non–volatile memory.	C
:SEQuence <seq_name>	Saves a sequence from the sequence scratchpad to non–volatile memory.	N
:WAVEform <wfrm_name>	Stores a waveform (trace) from the waveform scratchpad to non–volatile memory.	N

:UPload	Commands the SW Series to receive selected information from the host computer. An upload will put the data into a scratchpad area, which can then be saved to non–volatile memory. A waveform consists of 4096 12–bit data points. In ASCII format, 16386 bytes are required to be transferred; in Binary format, 8192 bytes. Example programs are contained in Appendix E.	C
:SEQuence	Upload to sequence scratchpad.	N
:WAVEform	Upload to waveform scratchpad.	N

2.7 OUTPUT SUBSYSTEM

Controls the output port; see Table 2–8.

Table 2–8. Output Subsystem

OUTPut	Output subsystem. This command may be followed by a boolean indicating the output terminal state (see STATe command). All phases are affected by this command.	C
:AUX <boolean>	Controls the state of the auxiliary relay. This is an option on some models. The *RST value is OFF.	N
:COUPling <AC¦DC>	Controls whether the output is in the AC or AC+DC mode. The *RST value is AC.	C
[:STATe] <boolean>	Controls whether the output terminals are open or closed. Valid arguments are ON (1) or OFF (0). The *RST value is OFF.	C

2.8 SOURCE SUBSYSTEM

The Source Subsystem consists of the commands listed in Table 2–9.

Table 2–9. Source Subsystem

SOURce[n]	n = 0, 1, 2, or 3. The default phase is 1 (phase A). To program all phases at the same time, use the LOCK command and program SOURce1 (phase A). A value of n = 0 will program all phases.	C
:CURRent	Programs the current level in the current foldback mode. This command may be followed by an amplitude. At *RST, the current amplitude is set to maximum.	C
[:LEVel]	Sets the output current amplitude. This command may be followed by an amplitude.	C
[:IMMediate]	Process the new amplitude without waiting for more commands. Must be followed by the :AMPLitude command.	C
[:AMPLitude] <value>	Sets the output current amplitude.	C
:PROTection	Programs the current level in the current shutdown mode. This command may be followed by a value.	C
:CLEar	Clears the protection circuit. This is the same as using the STATe OFF command.	C
:CURTimeout	Programs the current level in the current foldback mode for the value specified in TIMe, then reverts to the current shutdown mode for the current level specified.	N
:STATe (boolean>	Enable/disable the current mode timeout.	N
[:TIMe] <value>	Set the current mode timeout in ms.	N
:[LEVel] <value>	Sets the output level at which the output protection circuit will trip. At *RST, the value is set to maximum.	C

:STATe <boolean>	Enable/disable the protection circuit, At *RST, the value is on.	C
:TRIPped?	Returns a 1 if the protection circuit has tripped, an 0 if it is untripped. This query clears the tripped flag. A current limit shutdown will program the output voltage to 0 volts and open the output relay. To recover from a trip, the user must program the output voltage (and current limit if necessary) and close the output relay.	C
:LOCK <boolean>	Locks the current register of all three phases. Only phase A may be programmed, and any value programmed will affect all three phases.	N
:FREQuency <value>	The Frequency subsystem controls the output frequency of the unit. Note that a frequency change to any phase of a multi–phase unit will cause a frequency change in all phases of that unit. This command may be followed by a frequency value. At *RST, the value is set to 60 Hz.	C
:FUNCtion	The Function subsystem controls the shape and attributes of the output signal.	C
:LOCK <boolean>	Locks the function register of all three phases. Only phase A may be programmed, and any value programmed will affect all three phases.	N
:MODE <mode>	Determines which signal characteristic is being controlled. Possible values are VOLTage, CURRent or POWer. Only the VOLTage mode is currently implemented. At *RST, the mode is set to VOLTage.	C
[:SHAPe] <wfrm_name>	Selects the shape of the output signal. A complete list of standard waveform names is provided in Appendix B.	N

:PHASe	The Phase subsystem controls the phase offset (lag) of each phase relative to an internal reference. This command may be followed by a phase value. Phase offsets are programmed/queried in degrees. At *RST, phase A = 0°, phase B = 120°, and phase C = 240°.	C
:[ADJust] <value>	Controls the phase offset value relative to the reference.	C
:LOCK <boolean>	Locks the phase register of all three phases. Only phase A may be programmed, and any value programmed will affect all three phases.	N
:SEQuence		N
:NAME <seq_name>	Selects sequence to execute. A sequence name should be selected before SEQuence [:STATe] <boolean> is executed.	N
:[:STATe] <boolean>	Runs the sequence previously loaded in the sequence scratchpad.	N
:VOLTage	The Voltage subsystem controls the output signal amplitude. This command may be followed by a voltage value. At *RST, all outputs are set to 0 volts.	C
:[LEVel]	Programs the output voltage amplitude. This command may be followed by a voltage value.	C
[:IMMediate]	Process the command without waiting for further commands.	C
[:AMPLitude] <value>	Set the output voltage amplitude.	C
:PROTection	Programs the maximum **peak voltage** level at which the output protection circuit will trip. The overvoltage protection circuit cannot be disabled.	C
:[LEVel] <value>	Programs the maximum **peak voltage** level at which the output protection circuit will trip.	C

:STATe <boolean>	Enable/disable the protection circuit. This command is present for compatibility. The overvoltage circuit cannot be disabled. A query will always return a 1 (enabled).	C
:TRIPped?	Returns a 1 if the protection circuit has tripped, an 0 if it is untripped. This query clears the tripped flag. A voltage limit shutdown will program the output voltage to 0 volts and open the output relay. To recover from a trip, the user must program the output voltage and close the output relay.	C
:LOCK <boolean>	Locks the voltage register of all three phases. Only phase A may be programmed, and any value programmed will affect all three phases.	N
:RANGe <value>	Sets the output voltage range. The value can be 0 or 1, corresponding to 156 or 312 volts respectively. This command will cause all outputs to be programmed to 0 volts before the range change takes effect. At *RST, the range is set to 156 volts.	C

2.9 SYSTEM SUBSYSTEM

See Table 2–10.

Table 2–10. System Subsystem

SYSTem	System Subsystem	C
:BEEPer	This subsystem controls the audible beeper of the unit.	C
:STATe <boolean>	Enables/disables the beeper. Valid commands are ON (1) and off (0).	C
:TEST <boolean>	Turns the beeper on (1) and off (0).	C
:COMMunicate	This subsystem configures the communications interface.	C
:GPIB	This subsystem configures the GPIB interface.	C

:ADDRess <value> [,<value>]	Sets the GPIB address of the unit. The optional secondary addressing is not currently used. Power must be cycled before the new address will take effect.	C
:ERRor?	Query the error queue for the next error/event entry (queue is first in, first out). The entry contains an error number and descriptive text. A return value of 0 indicates no error occurred; negative numbers are reserved by the SCPI standard. The maximum return string length is 255 characters. The queue holds up to 10 errors/entries. All entries are cleared by the *CLS command.	C
:EXTernal		N
:DIRect <boolean>	Configures the amplifier reference signals to run from an internal source or external input on the rear panel.	N
:GAIN <boolean>	Enables/disables the external gain control from the rear panel input.	N
:LOWFREquency <boolean>	This option should be used for external AC input signals between DC and 40 Hz. It should not be used in normal operation, with an external DC input signal, or with frequencies above 40 Hz.	N
:MODulation <boolean>	Enables/disables the external modulation from the rear panel input.	N
:XLOAD <boolean>	This option can be used to reduce the undershoot, overshoot and ringing with unusual reactive loads. This option should not be used with normal loads.	N
:PHASe <THREE¦SINGLE>	Selects either a THREE or a SINGLE phase output. THREE phase mode means each phase can operate individually. SINGLE phase mode means all three phases are configured and operate as a single phase. **CAUTION: The rear panel wiring must agree with the software configuration.**	N

:VERsion?	Returns a numeric value corresponding to the SCPI version number for which the unit complies. The response is in the format YYYY.V where the Y's represent the year and V represents the approved version number for that year.	C

APPENDIX A

STATUS REGISTER

A1. STATUS REGISTER DEFINITIONS

The SW Series supports the IEEE 488.2 and SCPI 1993.0 status reporting data structures. These structures are comprised of status registers and status register enable mask pairs. These pairs are described below.

A1.1 Status Byte

The Status Byte status register can be read by the *STB? command or by issuing a GPIB serial poll. Either operation will clear the contents of the Status byte. The *CLS command will clear the Status Byte.

The SW Series unit can be configured to request service from the GPIB controller by setting the appropriate bits in the Service Request enable register. The SRE register has the same bit pattern as the Status Byte. The SRE register is modified using the *SRE command, and can be read with the *SRE? command.

For example, if the SRE register is set to 0x10 (MAV), when the SW Series unit has a message available, the Status Byte register will contain 0x50 (RQS and MAV) and the SRQ line of the GPIB bus will be pulled low indicating a request for service.

Bit	Hex Value	Description
0	01	Not used.
1	02	Not used.
2	04	Error/event queue message available.
3	08	Questionable Status flag. Indicates the quality of the current data being acquired. This bit is not used.
4	10	Message available (MAV).
5	20	Standard Event Status Register (ESR).
6	40	Request Service flag (RQS) for serial polling, or Master Summary Status (MSS) in response to ***STB?**
7	80	Operation Status flag. Indicates the current operational state of the unit. This bit is not used.

Bit 2, Error/event queue information available:
This bit is set when any error/event is entered in the System Error queue. It is read using the SYSTem:ERRor? query.

Bit 4, Message Available:
Indicates a message is available in the GPIB output queue. This bit is cleared after the GPIB output buffer is read.

Bit 5, Standard Event Status Register:

This is a summary bit for the ESR. It is set when any of the ESR bits are set, and cleared when the ESR is read.

Bit 6, Request Service/Master Summary Status:

If service requests are enabled (with the (SRE command) this bit represents the RQS and will be sent in response to a serial poll, then cleared. If RQS is not enabled, the bit represents the MSS bit and indicates the device has at least one reason to request service. Even though the device sends the MSS bit in response to a status query (*STB?), it is not sent in response to a serial poll. It is not considered part of the IEEE 488.1 Status Byte.

A1.2 Status Event Status Register

The ESR can be read by the *ESR? command. Reading this register or the *CLS command will clear the ESR.

Bits in the ESR will only be set when the corresponding bit in the Standard Events Status Enable register is set. Use the *ESE to set bits, and the *ESE? to read this register.

To configure the SW Series to generate SRQs based on the ESR, both the Standard Event Status Enable register and the Service Request Enable register must be programmed.

Bit	Hex Value	Description
0	01	Operation Complete
1	02	Request Control – not used.
2	04	Query Error.
3	08	Device Dependant Error.
4	10	Execution Error (e.g., range error).
5	20	Command Error (e.g., syntax error).
6	40	User Request – not used.
7	80	Power On.

Operation Complete:

Set whenever the last command is completed and the SW is ready to accept another command, or when query results are available.

Query Error:
Set when a query is made for which no response is available.

Device Dependant Error:
Set for device–specific errors. These errors are entered in the System Error Queue and have error codes greater than 0. See paragraph 3.6.15 for error descriptions.

Execution Error:
Set when a parameter exceeds its allowed range.

Command Error:
Set for a syntax error.

Power On:
Set once at power up. The Status Byte ESR is not set.

A1.3 Operation Status and Questionable Status Registers

The Operation Status and Questionable Status registers will always return 0 when queried. The Operation Status enable and Questionable Status Enable registers can be programmed and queried to allow SCPI compatibility, but have no effect on the Operation Status and Questionable Status registers.

A1.4 Error/Event Queue

The SW Series maintains and Error/ Event Queue as defined by SCPI. The queue holds up to 10 errors and events. It is queried using the SYSTem:ERRor? command, which reads in a first in, first out manner. The read operation removed the entry from the queue. The *CLS command will clear all entries from the queue.

A1.5 Serial Poll Operation

Performing a serial poll will not modify the Status Byte other than to clear the RQS (bit 6) for a SW requesting service. Queries affecting the status registers and subsequent serial polls are as follows:

*STB? clears the status Byte.

*ESR? clears the ESR and bit 5 of the Status Register.

SYSTem:ERRor? will clear bit 2 of the Status Register if the queue is empty.

NOTES

APPENDIX B

STANDARD WAVEFORMS

B1. STANDARD WAVEFORMS

The following standard waveforms are provided in the SW Series:

Name	Description
Clip0	A sine wave with the positive half–cycle clipped at 0V from 50° to 130°.
ClipPos	A sine wave with the positive half–cycle clipped from 50° to 130°.
ClipNeg	A sine wave with the positive half–cycle set to a 50% negative value from 50° to 130°.
DC+	Used to operate the SW as a positive DC source.
DC–	Used to operate the SW as a negative DC source.
DcRip03+	+DC with 3% ripple. The frequency of the ripple is determined by the programmed output frequency.
DcRip03–	–DC with 3% ripple. The frequency of the ripple is determined by the programmed output frequency.
DcRip10+	+DC with 10% ripple. The frequency of the ripple is determined by the programmed output frequency.
DcRip10–	–DC with 10% ripple. The frequency of the ripple is determined by the programmed output frequency.
Drop45	Sine with a dropout to 0V from 45° to 60°.
DropPk	Sine with a 100% dropout at 90° and 270°.
DropPk10	Sine with a 10% dropout at 90° and 270°.
FlatTp05	Flat–top sine wave with 5% distortion.
FlatTp10	Flat–top sine wave with 10% distortion.
FlatTp15	Flat–top sine wave with 15% distortion.
FlatTp20	Flat–top sine wave with 20% distortion.
Four3	Fourier square wave with 1st and 5th harmonics.
Four5	Fourier square wave with 1st, 3rd, and 5th harmonics.
Four7	Fourier square wave with 1st, 3rd, 5th, and 7th harmonics.
Four9	Fourier square wave with 1st, 3rd, 5th, 7th, and 9th harmonics.

Name	Description
FulRect+	Positive DC full rectified sine wave.
FulRect–	Negative DC full rectified sine wave.
Halfcyc	Sine wave with 90° to 180° at 0 volts.
HlfRect+	Positive DC half rectified sine wave.
HlfRect–	Negative DC half rectified sine wave.
Inrush	Sine wave with the first quarter (0° to 90°) at 0 volts.
Noisz010	Sine wave with 10% noise at zero crossings.
Noisz100	Sine wave with 100% noise at zero crossings.
Pcntl110	Phase control at 110°.
Pcntl170	Phase control at 170°.
Scratch	Waveform scratchpad. This is the waveform edit work area. Waveforms being edited can be output for testing purposes before they are saved to non–volatile memory.
Sine	Sine wave.
SinDc1+	Sine wave with +1% DC offset.
SinDc1–	Sine wave with –1% DC offset.
SinDc10+	Sine wave with +10% DC offset.
SinDc10–	Sine wave with –10% DC offset.
SinDc20+	Sine wave with +20% DC offset.
SinDc20–	Sine wave with –20% DC offset.
SinDc50+	Sine wave with +50% DC offset.
SinDc50–	Sine wave with –50% DC offset.
Spike200	Sine wave with spikes at the peaks. The spikes are from 85° to 95° and calibrated to be 200 Vpeak when programmed to 120 VRMS.
Spike250	Sine wave with spikes at the peaks. The spikes are from 85° to 95° and calibrated to be 250 Vpeak when programmed to 120 VRMS.
Spike300	Sine wave with spikes at the peaks. The spikes are from 85° to 95° and calibrated to be 300 Vpeak when programmed to 120 VRMS.

Name	Description
Spike400	Sine wave with spikes at the peaks. The spikes are from 85° to 95° and calibrated to be 400 Vpeak when programmed to 120 VRMS.
Square	Square wave with 50% duty cycle.
Step6	Six voltage step sine wave.
Step12	Twelve voltage step sine wave.
Step24	Twenty–four voltage step sine wave.
Taylor	5th harmonic Taylor series wave.
Triangle	Triangle wave.

NOTES

APPENDIX C

STANDARD SEQUENCES

C1. STANDARD SEQUENCES

The following standard sequences are provided in the SW Series:

Name	Description
FreqRamp	Frequency ramp from 60 to 400 Hz at 80 VRMS.
M704Fsag	MIL–704 frequency sag.
M704Fsrg	MIL–704 frequency surge.
M704Vsag	MIL–704 voltage sag.
M704Vsrg	MIL–704 voltage surge.
TEST1	Elgar voltage test sequence.

NOTES

APPENDIX D

ERROR CODES

D1. ERROR CODES

D1.1 Error Codes Returned by SYSTem:ERRor? Query

The following error codes are defined in the SCPI 1993.0 specification, and are supported by the SW Series. Error codes are in the range of [–32768, 32767]. SCPI reserves the negative error codes and 0, while error codes greater than 0 are device–specific errors.

Number	Title	Description
0	No Error	The error queue is empty.
–102	Syntax Error	An unrecognized command or data type was encountered.
–200	Execution Error	An error/event number in the range [–299, –200] indicates that an error has been detected by the unit's execution control block. The occurrence of any error in this class causes the execution error bit (bit 4) in the Event Status Register to be set. An execution error can be the result of: • A <program data> element out of range, such as programming 200 volts in the low (156 volt) range. • A command could not be executed due to the current condition of the device, such as attempting to change ranges while the output relay is closed. The output relay must be opened first.
–225	Out of Memory	There is not sufficient memory to perform the requested operation.
–241	Hardware Missing	A legal command or query could not be executed because the option is not installed.

Number	Title	Description
–284	Program Currently Running	A legal command or query could not be executed because a sequence is currently running.
–292	Referenced Name Does Not Exist	Self–explanatory.
–292	Referenced Name Already Exists	Self–explanatory.
–330	Self–Test Failed	Self–explanatory.
–350	Queue Overflow	The error queue can contain up to 10 entries. If more than 10 error/event conditions are logged before the SYSTem:ERRor? query, an overflow will occur; the last queue entry will be overwritten with error –350. When the queue overflows, the least recent errors/events remain in the queue and the most recent errors/events are discarded.

D1.2 Device–Specific Error Codes

Number	Title	Description
Fault Codes		
1	SHUTDOWN–F3:OV	Overvoltage shutdown.
2	SHUTDOWN–DC ERROR	Shutdown due to DC detected at the output.
3	ROV, RELAY OPEN	The output relay opened by the redundant overvoltage circuit.
4	SHUTDOWN–ROV	Shutdown by the redundant overvoltage circuit.
5	GND FAULT–RLY OPEN	The output relay opened by ground fault detection.
6	SHUTDOWN–GND FAULT	Shutdown by ground fault detection.
7	48V LOW–RLY OPEN	The output relay opened due to low housekeeping supply.

Number	Title	Description
8	SHUTDOWN–48V LOW	Shutdown due to low housekeeping supply.
9	F1:FF–RLY OPEN	Output relay opened due to cooling fan failure.
10	SHUTDOWN–F1:FF	Shutdown due to cooling fan failure.
11	F2:OV–OCCURRED	Overvoltage detected; DC buss voltage greater than 320V for 45 seconds. No action taken.
12	F2:OV–RLY OPEN	Output relay opened due to overvoltage condition.
13	SHUTDOWN–F2:OV	Shutdown due to overvoltage.
14	F4:OT–RLY OPEN	Output relay opened due to overtemperature.
15	SHUTDOWN–F4:OT	Shutdown due to overtemperature.
16	CURR LIMIT	Current limit detected.
17	CURRENT LIMIT	Output relay opened due to current limit.
18	RMS_OV–OCCURRED	Output RMS overvoltage detected.
19	RMS_OV–RLY OPEN	Output relay opened due to output RMS overvoltage.
20	ROC – SERVICE UNIT	Redundant overcurrent detected. Unit requires service.
21	SLAVE FAULT	Slave fault occurred.
22	SLAVE FAULT–RLY OPEN	Output relay opened due to slave fault.
23	Not Used	
24	OUTPUT RELAY FAULT	Output relay failed to open/close.
25	OUT RLY FAILED–5SEC	Output relay failed to open/close with 5 seconds.
26	ROV: SENSE LEAD ERR	Redundant overvoltage circuit detected sense lead error.

Number	Title	Description
50	MAXIMUM FREQUENCY EXCEEDED	When configured in the SYSTem:EXTernal:DIRect mode, the output frequency is monitored and the outputs will be programmed to 0V if the output frequency exceeds 5 kHz.
	Memory Errors	
100	ECDI EPROM Checksum Error	A power up or self–test checksum failure has occurred.
101	ECDI Non–Volatile RAM Bank 0 Checksum Error	A power up or self–test checksum failure has occurred.
102	ECDI Non–Volatile RAM Bank 1 Checksum Error	A power up or self–test checksum failure has occurred.
103	ECDI System RAM Failure	The volatile system RAM failed its memory test.
110	DWSB EPROM Checksum Error	A power up or self–test checksum failure has occurred.
111	DWSB Non–Volatile RAM Checksum Error	A power up or self–test checksum failure has occurred.
112	DWSB System RAM Failure	The volatile system RAM failed its memory test.
120	TEST BOARD EPROM Checksum Error	A power up or self–test checksum failure has occurred.
121	TEST BOARD System RAM Failure	The volatile system RAM failed its memory test.
	Calibration Errors	
200	OUTPUT VOLTAGE CALIBRATION	The output voltage calibration factor is out of range.
201	OUTPUT CURRENT CALIBRATION	The output current calibration factor is out of range.
202	MEASUREMENT SYSTEM ACTIVE	Cannot calibrate while the Measurement System is active. Clear all front panel measurements.

APPENDIX E

EXAMPLE PROGRAMS

E1. EXAMPLE PROGRAMS

E1.1 UPASCII.CPP – GPIB PROGRAM TO UPLOAD ASCII FILES TO ELGAR SW SERIES

```
/*-------------------------------------------------------------------------
 UPASCII.CPP - GPIB PROGRAM TO UPLOAD ASCII FILES TO ELGAR SW SERIES

 This program will read an ascii file of 16384 bytes (4096 waveform
 data points * 4 ascii characters per data point) and upload it
 to an Elgar SW 5250.  The file name is specified on the command line.
 Note that all uploads are sent to the Waveform Scratchpad area.  If
 multiple uploads are desired, each waveform must be saved from the
 waveform scratchpad to a user-defined memory location in the waveform
 library before the next waveform is uploaded.

 Initial release: 8/22/94 by Tom Kenney
-------------------------------------------------------------------------*/
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <dos.h>
#include "decl.h"                    // National Instruments GPIB header


/*-------------------------------------------------------------------------
 main
-------------------------------------------------------------------------*/
void main(int argc, char *argv[])
{
  char  FileName[20], DevName[20];
  char  *tempbuf;
  FILE  *fp;
  int   DevId;


        //----- initialize global variables -----
        strcpy(DevName, "SW5250");                    // device name

        //----- process command line arguments -----
        if (argc > 1)
    strcpy(FileName, argv[1]);
        else
        {
              printf("Usage: upascii <filename>\n");
    exit(0);
  }

  //----- open file to download -----
  if ((fp = fopen(FileName, "rt")) == NULL)
  {
    printf("Error opening %s \n", FileName);
    return;
  }

  //----- allocate temporary storage -----
  if ((tempbuf = (char *)malloc(17000)) == NULL)
  {
    printf("Error allocating memory\n");
    return;
  }

        //----- find gpib device -----
        printf("STARTING PROGRAM \n");
        if ((DevId = ibfind(DevName)) < 0)            // get device handle
        {
          printf("Could not find device %s \n", DevName);
          exit(1);
        }

  //----- identify device to confirm communications -----
```

```
    ibwrt(DevId, "*idn?", 5);                    // query id
            ibrd(DevId, tempbuf, 100);           // read string
    tempbuf[ibcnt] = '\0';                       // terminate string
            printf("Device id: %s \n", tempbuf);   // display


    //----- send upload commands -----
    ibwrt(DevId, "MMEM:FORMAT 0", 13);           // ascii format
    ibwrt(DevId, "MMEM:UPLOAD:WAVEFORM", 20);    // setup command

    //----- read file data and send to SW5250 -----
    fread(tempbuf, 1, 16384, fp);                // read all wfrm points
            ibwrt(DevId, tempbuf, 16384);        // send wfrm data

    //----- close input file and free memory -----
    fclose(fp);
    free(tempbuf);                               // free storage buffer
            printf("Sent ASCII waveform \n");
}
```

E1.2 DNASCII.CPP - GPIB PROGRAM TO DOWNLOAD AN ASCII FILE FROM AN ELGAR SW5250

```
/*-------------------------------------------------------------------------
 DNASCII.CPP - GPIB PROGRAM TO DOWNLOAD AN ASCII FILE FROM AN ELGAR SW5250

 A waveform may be downloaded from the Waveform Scratchpad in the
 SW5250.  This program will read an ascii file of 16384 bytes (4096 waveform
 data points * 4 ascii characters per data point) from the SW5250 and
 store it in a file specified on the command line.  Note that all downloads
 originate from the SW5250 waveform scratchpad area.  Therefore, a waveform
 must be loaded into the waveform scratchpad before this program execution.
 This can be accomplished either from the front panel or the
 MMEMory:LOAD:WAVEform GPIB command.  In this example, the desired
 waveform is loaded into the waveform scratchpad with a GPIB command before
 the download takes place.

 Initial release: 8/22/94 by Tom Kenney
 -------------------------------------------------------------------------*/
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <dos.h>
#include "decl.h"                    // National Instruments GPIB header

/*-------------------------------------------------------------------------
 main
 -------------------------------------------------------------------------*/
void main(int argc, char *argv[])
{
   char  DevName[20], WaveName[20], FileName[20];
   char  *tempbuf;
   FILE  *fp;
   int   DevId;


         //----- initialize global variables -----
         strcpy(DevName, "SW5250");                    // device name

         //----- process command line arguments -----
         if (argc > 2)
   {
      strcpy(WaveName, argv[1]);
      strcpy(FileName, argv[2]);
   }
         else
         {
               printf("Usage: dnascii <Waveform name> <File name>\n");
      exit(0);
   }

   //----- open file to store waveform -----
   if ((fp = fopen(FileName, "wt")) == NULL)
   {
      printf("Error opening %s \n", FileName);
      return;
   }

   //----- allocate temporary storage -----
   if ((tempbuf = (char *)malloc(17000)) == NULL)
   {
      printf("Error allocating memory\n");
      return;
   }

         //----- find gpib device -----
         printf("STARTING PROGRAM \n");
```

```
        if ((DevId = ibfind(DevName)) < 0)          // get device handle
        {
          printf("Could not find device %s \n", DevName);
          exit(1);
        }

//----- identify device to confirm communications -----
ibwrt(DevId, "*idn?", 5);                    // query id
        ibrd(DevId, tempbuf, 100);                  // read string
tempbuf[ibcnt] = '\0';                      // terminate string
        printf("Device id: %s \n", tempbuf);        // display

//----- send download commands -----
ibwrt(DevId, "MMEM:FORMAT 0", 13);                  // ascii format
sprintf(tempbuf, "MMEM:LOAD:WAVEFORM \"%s\"", WaveName);
ibwrt(DevId, tempbuf, strlen(tempbuf));             // load scratchpad
ibwrt(DevId, "MMEM:DOWNLOAD:WAVEFORM", 22);         // setup command

//----- read waveform data and write to file -----
ibrd(DevId, tempbuf, 16400);
fwrite(tempbuf, 1, ibcnt, fp);

//----- close file and free memeory -----
fclose(fp);
free(tempbuf);                              // free storage buffer
        printf("Received %d characters.  Created file: %s\n", ibcnt, FileName);
}
```

E1.3 UPBIN.CPP – GPIB PROGRAM TO DOWNLOAD ASCII FILES TO ELGAR SW SERIES

```
/*-------------------------------------------------------------------------
 UPBIN.CPP – GPIB PROGRAM TO DOWNLOAD ASCII FILES TO ELGAR SW SERIES

 This program will read a file of 8192 bytes (4096 waveform
 data points * 2 bytes per data point) and upload it to an Elgar SW 5250
 in the binary file format mode.  The file name is specified on the
 command line.
 Note that all uploads are sent to the Waveform Scratchpad area.  If
 multiple uploads are desired, each waveform must be saved from the
 waveform scratchpad to a user-defined memory location in the waveform
 library before the next waveform is uploaded.

 Initial release: 8/22/94 by Tom Kenney
 -------------------------------------------------------------------------*/
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <dos.h>
#include "decl.h"                    // National Instruments GPIB header

short    Wfrm[4096];       // waveform storage

/*-------------------------------------------------------------------------
 main
 -------------------------------------------------------------------------*/
void main(int argc, char *argv[])
{
   char  FileName[20], DevName[7], tempbuf[80];
   FILE  *fp;
   int   DevId, i;

         //----- initialize global variables -----
         strcpy(DevName, "SW5250");                    // device name

         //----- process command line arguments -----
         if (argc > 1)
      strcpy(FileName, argv[1]);
         else
         {
               printf("Usage: upbin <filename>\n");
      exit(0);
   }

         //----- find gpib device -----
         printf("STARTING PROGRAM \n");
         if ((DevId = ibfind(DevName)) < 0)            // get device handle
         {
           printf("Could not find device %s \n", DevName);
           exit(1);
         }

   //----- identify device to confirm communications -----
   ibwrt(DevId, "*idn?", 5);                  // query id
         ibrd(DevId, tempbuf, 100);                  // read string
   tempbuf[ibcnt] = '\0';                     // terminate string
         printf("Device id: %s \n", tempbuf);  // display

   //----- open file to download -----
   if ((fp = fopen(FileName, "rb")) == NULL)
   {
      printf("Error opening %s \n", FileName);
      return;
   }
```

```
    //----- send upload commands -----
    ibwrt(DevId, "MMEM:FORMAT 1", 13);          // binary format
    ibwrt(DevId, "MMEM:UPLOAD:WAVEFORM", 20);   // setup command

    //------ read file data and send to SW5250 -----
    fread(Wfrm, sizeof(short), 4096, fp);       // read all wfrm points
            ibwrt(DevId, (char *)Wfrm, 8192);           // send wfrm data

    //----- close input file and free memory -----
    fclose(fp);
            printf("Sent binary waveform \n");
}
```

E1.4 DNBIN.CPP – GPIB PROGRAM TO DOWNLOAD BINARY WAVEFORM FILES TO AN ELGAR SW5250

```
/*-------------------------------------------------------------------------
 DNBIN.CPP – GPIB PROGRAM TO DOWNLOAD BINARY WAVEFORM FILES TO AN ELGAR
        SW5250

 This program will read a file of 8192 bytes (4096 waveform data
 points * 2 bytes per data point) from an Elgar SW 5250 in the binary
 file format mode.  The file is written to the file name specified on the
 command line.  Note that all downloads originate from the SW5250
 waveform scratchpad area.  Therefore, a waveform must be loaded into
 the waveform scratchpad before this program execution.  This can be
 accomplished either from the front panel or the MMEMory:LOAD:WAVEform
 GPIB command.

 Initial release: 8/22/94 by Tom Kenney
 -------------------------------------------------------------------------*/
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <dos.h>
#include <ctype.h>
#include "decl.h"                    // National Instruments GPIB header

//----- function prototypes -----
short swap_short(short  n);

//----- global variables -----
short   Wfrm[4096];       // waveform storage

/*-------------------------------------------------------------------------
 main
 -------------------------------------------------------------------------*/
void main(int argc, char *argv[])
{
   char  FileName[20], DevName[20], tempbuf[80];
   FILE  *fp;
   int   DevId, i;

   //----- initialize variables -----
   strcpy(DevName, "SW5250");                          // device name

   //----- process command line arguments -----
   if (argc > 1)
      strcpy(FileName, argv[1]);
   else
   {
      printf("Usage: dnbin <filename>\n");
      exit(0);
   }

   //----- open file to download -----
   if ((fp = fopen(FileName, "wb")) == NULL)
   {
      printf("Error opening %s \n", FileName);
      return;
   }

   //----- find gpib device -----
   printf("STARTING PROGRAM \n");
   if ((DevId = ibfind(DevName)) < 0)          // get device handle
   {
      printf("Could not find device %s \n", DevName);
      exit(1);
   }

   //----- identify device to confirm communications -----
```

```
    ibwrt(DevId, "*idn?", 5);              // query id
    ibrd(DevId, tempbuf, 80);              // read string
    tempbuf[ibcnt] = \0';                  // terminate string
    printf("Device id: %s \n", tempbuf);   // display


    //----- send download commands -----
    ibwrt(DevId, "MMEM:FORMAT 1", 13);          // binary format
    ibwrt(DevId, "MMEM:DOWNLOAD:WAVEFORM", 22); // download scratchpad data

    //----- read waveform binary data and write file -----
            ibrd(DevId, (unsigned char *)Wfrm, 8200);       // get wfrm data
    for (i = 0; i < 4096; i++)
       Wfrm[i] = swap_short(Wfrm[i]);
    fwrite(Wfrm, sizeof(short), 4096, fp);          // write all wfrm points

    //----- close input file -----
    fclose(fp);
            printf("Created file: %s \n", FileName);
}


/*-------------------------------------------------------------------------
 Swaps the upper and lower bytes of a short integer
 -------------------------------------------------------------------------*/
short swap_short(short   n)
{
    union {
       unsigned char  byte[2];
       short          word;
    } number;

    unsigned char     tempchar;


    number.word = n;
    tempchar = number.byte[0];
    number.byte[0] = number.byte[1];
    number.byte[1] = tempchar;

    return (number.word);
}
```

E1.5 ATOBIN.CPP – PROGRAM TO CONVERT ASCII WAVEFORM FILES TO BINARY

```
/*-------------------------------------------------------------------------
 ATOBIN.CPP - PROGRAM TO CONVERT ASCII WAVEFORM FILES TO BINARY

 This program will read an ascii file of 16384 bytes (4096 waveform
 data points * 4 ascii characters per data point) and convert it
 to a binary file.  The file name is specified on the command line.

 Initial release: 8/22/94 by Tom Kenney
-------------------------------------------------------------------------*/
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <dos.h>
#include <ctype.h>

unsigned short hex_to_word(char *s);

short    Wfrm[4096];

/*-------------------------------------------------------------------------
 main
-------------------------------------------------------------------------*/
void main(int argc, char *argv[])
{
   char  FileName[20], PointStr[20];
   char  *tempbuf;
   FILE  *fp;
   short i, buf_ctr;


         //----- process command line arguments -----
         if (argc > 1)
      strcpy(FileName, argv[1]);
         else
         {
               printf("Usage: atobin <filename>\n");
      exit(0);
   }

   //----- open file to read -----
   if ((fp = fopen(FileName, "rt")) == NULL)
   {
      printf("Error opening %s \n", FileName);
      return;
   }

   //----- allocate temporary storage -----
   if ((tempbuf = (char *)malloc(17000)) == NULL)
   {
      printf("Error allocating memory\n");
      return;
   }

   //----- read file data and send to SW5250 -----
   fread(tempbuf, 1, 16384, fp);              // read all wfrm points
   fclose(fp);

   buf_ctr = 0;
   for (i = 0; i < 4096; i++)                 // convert to binary
   {
      PointStr[0] = tempbuf[buf_ctr++];
      PointStr[1] = tempbuf[buf_ctr++];
      PointStr[2] = tempbuf[buf_ctr++];
      PointStr[3] = tempbuf[buf_ctr++];
      PointStr[4] = '\0';
```

```
    Wfrm[i] = hex_to_word(PointStr);
  }

  //----- create file name with ".bin" extension -----
  i = 0;
  while ((FileName[i] != '.') && (FileName[i] != '\0'))
    i++;
  FileName[i] = '\0';
  strcat(FileName, ".bin");

  //----- open file to read -----
  if ((fp = fopen(FileName, "wb")) == NULL)
  {
    printf("Error opening %s \n", FileName);
    return;
  }

  fwrite(Wfrm, sizeof(short), 4096, fp);       // write binary wfrm points
  fclose(fp);

  free(tempbuf);                               // free storage buffer
        printf("Created file: %s \n", FileName);
}


/*-------------------------------------------------------------------------
 Converts 4 hexadecimal characters to a 16-bit value
 -------------------------------------------------------------------------*/
unsigned short hex_to_word(char *s)
{
  unsigned short  hex_val, i;

  hex_val = 0;
  for (i = 0; i < 4; i++)
  {
    hex_val <<= 4;

    if (s[i] <= '9')
      hex_val += s[i] - 0x30;
    else
      hex_val += toupper(s[i]) - 0x37;
  }

  return(hex_val);
}
```

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